Municipal Water Infrastructure Efficiency as the Least Cost Alternative

Alliance to Save Energy (ASE)

WORKING PAPER

This working paper is being published with the sole objective of contributing to the debate on a topic of importance to the Bank and the region and to elicit comments and suggestions from interested parties. The paper has not gone through the Department's peer review process or undergone consideration by the SDS Management Team. As such, it does not represent the official position of the Inter-American Development Bank. Please direct your comments to Silvia Ortiz, Environment Division, silviaor@iadb.org.

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ACRONYMS

ADB	Asian Development Bank
ADERASA	Association of Water and Sanitation Regulatory Entities of the Americas (*Asociación de Entes Reguladores de las Americas*)
ANEAS	National Association of Water and Wastewater Companies (Mexico) (*Asociación Nacional de Empresas de Agua y Saneamiento*)
ANEEL	National Electric Energy Agency (Brazil) (*Agência Nacional de Energia Elétrica*)
APAZU	Drinking Water, Wastewater and Sanitation Program in Urban Areas (Mexico) (*Programa de Agua Potable, Alcantarillado y Saneamiento en Zonas Urbanas*)
ASCE	American Society of Civil Engineers
ASSEMAE	National Association of Municipal Sanitation Service Providers (Brazil) (*Associação Nacional dos Serviços Municipais de Saneamento*)
AWWA	American Water Works Association
BANOBRAS	National Bank for Public Works and Public Services (Mexico) (*Banco Nacional de Obras y Servicios Publicos*)
BNDES	National Bank for Economic and Social Development (Brazil) (*Banco Nacional de Desenvolvimento Econômico e Social*)
CAGECE	Water and Wastwater Utility of Ceará, Brazil (*Companhia de Água e Esgoto do Ceará*)
CEA	State Water Commission (Mexico) (*Comisión Estatal de Agua)*
CEF	Federal Economic Fund (Brazil) (*Caixa Economica Federal*)
CEPEL	Electric Energy Research Center (Brazil) (*Centro de Pesquisa de Energia Elétrica*)
CESB	State Basic Sanitaion Companies (Brazil) (*Companhias Estaduais de Saneamento Básico)*
CFE	Federal Electricity Commission (Mexico) (*Comisión Federal de Electricidad*)
CLASP	Collaborative Labeling and Appliance Standards Program
CNA	National Water Commission (Mexico) *(Comisión Nacional del Agua*)
COELCE	Electric Energy Utility in Ceará, Brazil (*Companhia Energética do Ceará*)
COMAPA	Municipal Commission of Potable Water, Sewage and Sanitation of Reynosa, Tamaulipas, Mexico

CONAE	National Energy Savings Commission (Mexico) (*Comisión Nacional de Ahorra de Energía*)
COSAMA	State Water and Sanitation Utility of Manaus (Brazil)
DFID	Department for International Development (United Kingdom)
EFEI	Federal University at Itajuba, Minas Gerais (Brazil)
EIA/RIMA	Environmental Impact Assessment (*Estudo de Impacto Ambiental/Relatório de Impacto Sobre o Meio Ambiente*)
EMBASA	State Water and Sanitation Company of Bahia (Brazil)
ESCO	Energy Service Company
FAT	Worker Safety Fund (Brazil) (*Fundo de Amparo ao Trabalhador*)
FCP-SAN	Financing Program for Private Sanitation Services Concessionaires
FGTS	Fund for Guarantee of Time of Service (Brazil) (*Fundo de Garantia de Tempo de Serviço)*
FIDE	Trust to Save Energy (Mexico) (*Fideicomiso para el Ahorro de Energia*)
FNMA	National Fund for the Environment (Brazil) (*Fundo Nacional do Meio Ambiente*)
GIS	Geographic Information System
IBAM	Brazilian Institute of Municipal Administration (*Instituto Brasileiro de Administração Municipal*)
IBNET	International Benchmarking Network For Water and Sanitation Utilities
IBRD	International Bank for Reconstruction and Development
IDB	Inter-American Development Bank
ILI	Infrastructure Leakage Index
IMTA	Mexican Institute of Water Technology (*Instituto Mexicano de Tecnología del Agua*)
IPMVP	International Performance Measurement and Verification Protocol
KUWSDB	Karnataka Urban Water Supply and Drainage Board
MUNEE	Municipal Network for Energy Efficiency
NADBank	North American Development Bank
NRW	Non-Revenue Water
O&M	Operations and Maintenance
OGU	General Budget of Brazil

PAS	Sanitation Action Program (Brazil) (*Programa de Acciones de Saneamiento*)
PASS/IBD	Program for Social Action in Sanitation (Brazil)
PAT-PROSANEAR	Project for Technical Assistance for Sanitation Programs for Populations in Low-Income Areas (Brazil)
PDLI	Local Integrated Development Plans (Brazil) (*Planos de Desenvolvimento Local Integrado*)
PMEC	Improvement of Efficiency in Zones Program (Mexico)
PMSS	Sanitation Sector Modernization Program (Brazil) *(Programa de Modernização do Setor Saneamento)*
PNH	National Hydraulic Plan (Brazil) (*Plano Hidráulico Nacional*)
PROCEL	Fight Against Electricity Waste Program (Brazil) (*Programa de Combate ao Desperdicio de Energia Eletrica*)
PRODDER	Tax Return Program (Mexico) (*Programa de Devolución de Derechos*)
PRODDI	Demonstration Program for Institutional Development in Drinking Water and Sanitation (Mexico) (*Programa de Atención a la Frontera Norte: Programa Demostrativo de Desarrollo Institucional en Agua Potable y Saneamiento*)
PROMAGUA	Water Sector Moderization Program (Mexico) (*Programa de Modernización del Sector Agua)*
PROSEGE	Emergency Program for Generation of Employment in Sanitation Projects (Brazil) (*Programa Emergencial de Geração de Emprego em Obras de Saneamento*)
PROSSAPYS	Drinking Water and Sanitation Services Sustainability Program in Rural Communities (Mexico) (*Programa para la Sostenibilidad de los Servicios de Agua Potable y Saneamiento en Comunidades Rurales*)
PSI	Integrated Sanitation Projects (Brazil) (*Projetos de Saneamento Integrado*)
SAS	Metropolitan System of Water and Sanitation of Veracruz, Mexico
SCADA	Supervisory Control and Data Acquisition
SEDU	Special Secretary of Urban Development
SNIS	National Sanitation Information System (Brazil) *(Sistema Nacional de Informações Sobre Saneamento)*
USAID	United States Agency for International Development
WHO	World Health Organization

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I. Executive Summary

The Millennium Development Goals call for aggressive action to bring water to the world's poor. The official goal for water seeks to halve the number of people without access to drinking water in the fifteen years from 2001 through 2015. Meeting Millennium Development Goals in Latin America will require connecting an estimated 9 million people annually. In Latin America, the cost of meeting these goals is estimated by the Inter-American Development Bank to be between US$ 570 million and US$ 1.15 billion every year, depending on how much of the improved access is standpipes versus in-home connections, for a total of up to US$17.2 billion by 2015. The predictions for Brazil and Mexico are also daunting, with mid-range estimates of US$ 362 million and US$ 227 million per year, respectively. The water challenge is further compounded by water systems that are already in default and where the cost of providing water is greater than revenues collected.

> A development agenda that maximizes the capacity of existing infrastructure through efficiency before encouraging new construction is the most cost-effective and sustainable way to meet Latin America's water needs.

The integral relationship between water and energy is not widely understood or sufficiently exploited through coordinated efficiency approaches. The water-energy relationship is based on the reality that treating water for human consumption and moving treated water to the consumer is an extremely energy intensive undertaking. Surface and ground water sources require expensive pumping, treatment, and conveyance systems.

Traditional approaches to water supply have worked reasonably well in industrialized economies, but their suitability for the developing world is increasingly being questioned as the need for increased water access grows exponentially there. By 2020, over 50% of the population in developing countries will live in urban areas, yet the cost of using traditional approaches to provide this population with water infrastructure is well beyond the means of most underserved communities, and places an ever increasing strain on national and provincial governments. Politically sensitive though it can be, governments generally now understand that water provision must be managed through consumption-based pricing. This is necessary to preserve the limited resources of water and energy—although energy is often overlooked in the water sector—and to preserve the financial viability of water provision over the long-term. Incorporating efficiency into water supply, including the design of water infrastructure systems, is a critical means of controlling costs while expanding access.

This paper demonstrates that water access can be expanded in Mexico and Brazil more quickly and inexpensively through efficiency. Energy and water efficiency, when applied within an integrated planning process, can defer and in some cases eliminate the need for additional infrastructure investment. Efficiency improvements in municipal water utilities are also worthwhile investments because they provide impressive returns in the form of operational and overhead savings, superior service, and improved financial sustainability.

The Costs of Inefficiency

Water and wastewater investment decisions that neglect energy efficiency have a domino effect that increases investments in other sectors. For example, an estimated US$ 30 billion is required

for new electric generating plants needed to power the new water infrastructure to serve the approximately two billion under-provided urban inhabitants expected around the world by 2025. Efficiency in water supply and wastewater treatment decreases the need for new power plants, as well as a wide range of other costs such as the environmental and operational costs of new power plants, operating expenses for water distribution and treatment, additional investments to extract and transport the additional fuel, and environmental costs due to emissions and declining water and hydrocarbon reserves.

Every liter of water that passes through a system represents a significant energy cost. To provide water to the greatest number of people with the lowest drain on limited resources, efficiency measures must be incorporated into infrastructure planning in order to minimize the concomitant demands on energy, water and finances. In Mexico and Brazil, overall energy costs consume 32% to 40% of the gross revenues of water utilities, making efficiency a low-risk, cost-effective way of improving the financial viability of utilities while stretching limited water and energy resources. Results obtained in Mexico—considered similar to those occurring in most Latin American countries—show that more than one-third of the volume of water supplied is lost before the cost of the water can be recovered. Also lost is the energy embodied in that water, from pumping, treating and conveying it. In Brazil an average of 44% of water is lost to leaks and system inefficiencies. Water losses alone waste 3.5 billion kWh per year in Brazil, to say nothing of inefficient machinery or pumping systems, costing the water sector an additional US$ 230 million per year.

Water currently lost to leaks in Mexico, if recovered, could cover the expected growth in demand there for the next six years, meeting future needs, diminishing current shortfalls, and postponing investments in infrastructure.

Opportunities from Efficiency

Energy and water efficiency in the water sector is technologically accessible and highly cost-effective. The magnitude of potential energy savings documented in case studies—between 10 and 40%—provides a significant boost to a water utility struggling to provide services. Water currently lost to leaks in Mexico, if recovered, could cover the expected growth in demand there for the next six years, meeting future needs, diminishing current shortfalls, and postponing investments in infrastructure. Installation of modern efficient consumer equipment can also dramatically decrease energy and water consumption. For example, using a horizontal-axe clothes washer instead of a traditional vertical-axe one can save $100 annually in energy and water costs.

Water sector efficiency is so cost-effective that it can be thought of as safe, high yield investment to generate a significant portion of funds needed to finance new water infrastructure. Data gathered from Alliance to Save Energy projects in Brazil and Mexico demonstrate that:

- ✓ Every dollar invested in combined water and energy saving measures in the water sector returns nine dollars on average. Although the amounts of water and energy saved vary depending on the specific technologies and improvements, water efficiency projects always provide high rates of return on investment.
- ✓ The average rate of return on energy efficiency investments in the water sector is about 80% every year over a ten year period, providing investments with an average one-year payback period.

Risk averse financial institutions and the relatively small size of water efficiency projects have remained stubborn barriers for utilities and energy service companies to obtain external financing for such projects, even for inherently low risk performance contracting mechanisms that ensure the servicing debt through savings from the project.

The following case studies from Brazil and Mexico illustrate the cost-effectiveness of using efficiency to save money, water and energy:

- In Fortaleza, Brazil, another 88,000 homes have running water, due to a collaboration between CAGECE, the northern Brazilian State of Ceara's water utility, and the Alliance to Save Energy. Through system redesigns and equipment upgrades, CAGECE has been able to reduce its total energy use by 8% from 2000 levels and save US$ 45,000 per month, while at the same time increasing access to potable water to those in need.

- In Veracruz City, Mexico, faced with over 100 service complaints per month, high energy bills, and rising water loss rates, the Metropolitan System of Water and Sanitation at Veracruz (SAS) worked with the Alliance to identify energy efficiency potential in their system. SAS optimized electromechanical efficiency in their pump and motor systems, resulting in a 24% reduction in energy use and a savings of 153,254 kWh/month, with a payback period of 1.7 years. Water losses are decreasing, and customer complaints now occur less than once per month.

- In Querétaro City, Mexico huge water losses of over 50% were tackled with a metering system, leak repairs, improvements in pumping efficiency, and the identification of non-paying customers. The project repaired 7,600 leaks and registered 5,800 previously non-paying users, for annual savings of 5.3 million m^3 in water, 3.2 GWh of electricity, and US$ 4.0 million.

RECOMMENDATIONS

The recommendations produced by this study are summarized below, outlining ways that governments, donors, and multilateral development banks can make the provision of clean water more cost effective through the promotion of water sector efficiency. The recommendations are divided into two types: those that fall in the realm of the public sector, while the other is probably best carried out through technical assistance funded by bilatral and multilateral donors and/or multilateral development banks, in cooperation with governments.

Public Sector

❶ *Benchmarking Indices* – Economic incentives that reward and motivate improved energy and water efficiency can be bolstered by indices designed for water utilities, established by federal agencies and maintained either by these agencies or reliable designated organizations. Some networks of water sector indicators do exist, but they do not capture energy data and none of them adequately inform decision makers as to what investments should be made in efficiency versus new infrastructure.

❷ *Incentives* – Economic incentives and legal frameworks that allow performance contracting to flourish, and incentives that give funding priorites to those water utilities that commit to including energy efficinecy into their operations and planning.

❸ *Standards* – National governments can drive the market penetration for efficiency by developing and adopting energy and water efficiency standards for consumer water- and energy-consuming appliances and water and wastewater system design and procurement.

❹ *Tariffs* – Governments must put in place incremental processes to systematically remove financial disincentives to conserving energy and water, such as flat-fee tariffs and price-distorting subsidies, and replace them with consumption-based tariffs, balanced by subsidies targeted to poor households, which encourage energy and water conservation and efficiency while still allowing for universal service delivery. An intensive public awareness campaign will be required to educate consumers that charging for water based on consumption is necessary to ensure an ample supply of clean water now and for future generations. Transparent muncipal processes for incurring fee increases and public participation in municipal decision-making, including water and energy conservation programs, will act to counterbalance rising water tarrifs. Governments should consider phasing in progressively more sophisticated, and costly, levels of water service to customers who cannot shoulder the burden of rising water tarrifs due to increased demand rather than attempting to provide expensive in-home connections all at once.

Donor Assistance

❺ *Guidelines to Reduce Transaction Costs for Water Sector Efficency Projects* – Fund an organization that specializes in water sector energy efficiency to create a streamlined set of guidelines for financial institutions to use in Latin America to quickly process energy efficiency projects.

❻ *Technical Assistance and Demonstrations for Utilties and Financial Institutions* – Technical assistance to support a set of pilot water utilities to develop the entire process of incorporating energy efficiency: from audits to obtaining financing, through to monitoring and verifying results, including quantifying and documenting the resulting carbon emission reductions. Provided that the demonstrations are numerous enough to reach a critical mass, and the results are thoroughly disseminated, this approach will generate capacity and demand for water sector efficiency.

❼ *Capacity Building within Financial Instiutions* - In parallel, build capacity in the financial institutions on lending for energy efficiency projects (including the use of the guidelines). Broadly disseminate the results to municipalities and water utilities, financial institutions, and appropriate government agencies.

II. Introduction

Meeting Millennium Development Goals for water in Latin America will cost $1.15 billion per year, reaching a total of US$17.2 billion by 2015.[1] Resource challenges are compounded in a scenario where water systems are already in deficit and where the cost of providing water is greater than the revenues collected. In addition to the economic impediments of clean water provision, water scarcity is a major issue in many areas of the region. The issue of water has and will continue to be a focal point in Latin America and around the world.

The past decade has seen sustained efforts the international community to reduce poverty while working to help the world's poor gain an economic foothold. Rooted in the belief that increased growth will lead to improved lives, providing water access to the millions that are currently lacking is an important foundation of poverty alleviation. The poor pay a premium for water, and are often forced to purchase it from middlemen. Water vendors are an irregular source of water, and their services often translate into water costs nine times that paid by those connected to formal water networks. Even where networks exist, a water connection does not guarantee ready water access. In India, entire towns can go several days before water arrives at the tap, prompting a rush to replenish residential water tanks.

> In Mexico and Brazil energy costs consume 32% to 40% of the gross revenues of water utilities, making efficiency a low-risk, cost-effective way of improving the financial viability of utilities and stretching limited water and energy resources.

All sectors of society—government, development institutions, NGOs, academia, and the private sector—have shifted the burden of providing sustainable solutions to such an enormous challenge. Private sector participation is often heralded as a panacea for providing access to the underserved, yet when applied, it is not uncommon that the private sector shoulders the blame once weaknesses in local governance, regulation and historical water system maintenance are revealed. Even Brazil, where conditions were once thought to be ready for large-scale rollout of privatization models, has been slow to adopt these options. There is no single solution to the region's water access challenges, and only through focused introspection and an analysis of resource use within existing systems, does energy efficiency emerge as a powerful opportunity for savings. Energy is among the top three costs to water utilities globally, often coming second after labor costs. In Mexico and Brazil energy costs consume 30 to 40% of the gross revenues of water utilities, making efficiency a low-risk, cost-effective way of improving the financial viability of utilities and stretching limited water and energy resources.

An integral relationship exists between water and energy that is not widely understood, and even more infrequently exploited through concerted efficiency approaches. This relationship is based on the reality that preparing water for human consumption and moving treated water to the consumer is an extremely energy intensive undertaking. Surface water sources require expensive pumping, treatment, and conveyance systems. Ground water is pumped from aquifers of varying quality and depth that suffer increasingly from contamination and

[1] Inter-American Development Bank, *The Millennium Development Goals and the investment needs in Latin America and the Caribbean*, (original text in Spanish: *La Metas del Milenio y las necesidades de inversión en América Latina y el Caribe*), Sustainable Development Department, October 2003.

overexploitation. Both sources are finite resources and are increasingly subject to competing demands placed on them by industrial, residential, and most significantly, agricultural uses.

Traditionally, the water sector has maintained a strong focus on expanding access and improving water quality. Often this approach has been to the exclusion of any efficiency component that might ease pressures on already stretched resources. By reducing manageable input costs like energy and water, an economic balance can be achieved, often while reducing the need for new and expensive conveyance infrastructure.

Traditional approaches will not move Latin America to sustainable and equitable water access. A paradigm shift must take place, one that redirects resources towards projects that account for the lifecycle costs of entire systems rather than focusing solely upon the lowest initial capital investment costs. Given the tools and knowledge required to bring accountability for energy and water use within the sector, governments can be weaned away from the distortion created by flat-fee tariffs for energy and water consumption.

Manufacturers in Europe and the United States have come to view energy efficiency as a means to improving their bottom-line. Within the manufacturing sector, energy is largely viewed as a manageable cost, and one that can lead to reduced production costs and an improved bottom line through investment in both technology and staff capacity. These companies have come to understand that, using technologies that are readily available, energy efficiency investments have rapid payback periods. In the water sector, the greatest obstacle to large-scale implementation of efficiency stems from the lack of technical expertise both at the management and technician level. The water sector languishes in a climate where few efficiency examples serve as models for implementing these initiatives on any meaningful scale.

Efficiency improvements in municipal water utilities are worthwhile investments that provide impressive returns in the form of operational and overhead savings, superior service, and improved financial sustainability.

Brazil and Mexico are the economic engines of Latin America and yet are burdened by large public debt that will constrain further investment in new water infrastructure. Each country is different in their approach to water provision and in their approach to water and energy resource management. This paper demonstrates the efficiency opportunities that exist within the water sector, focusing on Brazil and Mexico to make this case, a case that can be extrapolated to the rest of Latin America.

In keeping with the Inter-American Development Bank (IDB) strategy for Brazil, social and regional disparities in access to water and sanitation services can be mitigated when efficiency allows municipalities to redirect capital consumed by energy bills into increasing water access for underserved populations. Alliance experience with water and energy efficiency found this to be true in the northeast of Brazil, where water is scarce and high levels of poverty are common. Efficiency can also be an entry point for the private sector, part of the IDB strategy for Mexico, in operations and maintenance of water and sanitation systems through mechanisms such as performance contracting. Whether efficiency is implemented by the public sector within their own facilities, or in conjunction with private service providers, it will be crucial to take advantage of the energy and water savings opportunities revealed in the following analysis.

III. Water and Wastewater Provision in Mexico and Brazil

Latin America has seen an 11% increase in access to an improved water supply from 1990 to 2002, mostly in urban areas.[2] The region reports access to water in urban areas at 95%, very close to universal access.[3] Rural areas report 69% coverage, for a weighted average for the entire region of 89%. The Millennium Development Goals strive for aggressive improvement by 2015, halving the proportion of people without access to drinking water. Meeting this goal would require connecting an estimated additional 9 million people in Latin America each year. This paper demonstrates that for the cases of Mexico and Brazil, it is far more cost effective to meet this objective through the broad application of water and energy efficiency measures, which will greatly reduce the need for costly new water and energy infrastructure. In the following sections, the cost of improving water and wastewater services to Millennium Goal levels is estimated and methods of financing these improvements to meet projected needs are suggested.

A. Brazil

With the exception of the semi-arid Northeast, Brazil is one of the richest countries in fresh water in the world, with close to 14% of the world's available fresh water.[4] However, water availability varies greatly, both seasonally and geographically, in different regions of the country. Demographic patterns and economic growth in Brazil have increased pressure on water resources, provoking situations of water scarcity or conflicts between users in various regions of the country.

The sanitation sector in Brazil is gravely deficient in serving the population, especially the populations of the lowest income brackets. The national indices for water supply (89%)[5] and sewerage (75%) are still far from universal service coverage. In addition, as a result of the unequal distribution of investment among states, and among regions of the same state or municipality, most of the unmet needs are concentrated in the peripheries of large cities, the smallest municipalities, and rural areas.

Brazil's model for the provision of water and sanitation services was established during the 1970s and based largely around a system of state utilities. The provision of services is concentrated in 251 State Basic Sanitation Companies or Companhias Estaduais de Saneamento Básico (CESBs). CESBs offer water supply services through concessions in 70%

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[2] *Joint Monitoring Programme for Water Supply and Sanitation*, World Health Organization, 2002. Available online at http://www.wssinfo.org/en/238_wat_latino.html, last accessed January 25, 2005.

[3] Access to water-supply services is defined as the availability of at least 20 liters per person per day from an "improved" source within 1 kilometer of the user's dwelling. An "improved" source is one that is likely to provide "safe" water, such as a household connection, a borehole, etc. Current information does not allow WHO to establish a relationship between access to safe water and access to improved sources, but WHO and UNICEF are examining this relationship.

[4] *National Sanitation Informaiton System,* (original text in Portuguese: *Sistema Nacional de Informações Sobre Saneamento)* (SNIS), Programa de Modernização do Setor de Saneamento (PMSS) (Sanitation Sector Modernization Program), Ministério de Cidades, 2003. Available online at http://www.snis.gov.br/.

[5] WHO 2002.

or 3,835 municipalities in the country, whose urban population represents 74% of the urban population. Close to 95 million people are served by CESBs, including 77% of Brazil's urban population. In these municipalities, average urban coverage is 94%. Coverage is lower in sewerage services, where the CESBs are responsible for sewerage service in only 762 municipalities, only 14% of the total. The CESBs generally provide sewerage services to the capitals and largest cities of their respective states.[6] Despite serving only a few municipalities, the population served is 39.8 million, or close to 51% of the total number of people in the country served by collection or runoff networks.

Municipal service companies are responsible for providing services in the remaining Brazilian municipalities, with the large majority organized as autonomous agencies. Data for 1994 from the National Association of Municipal Sanitation Service Providers (ASSEMAE) (*Associação Nacional dos Serviços Municipais de Saneamento*),[7] indicate that 64% of municipal service companies were concentrated in the Southeast serving 61.5% of the population served by municipal water providers.

Private sector participation in water service provision is currently limited to 60 municipal concessions, full or partial, concentrated in the Southeast and Mato Grosso. The largest cities with private concessionaires are Manaus and Campo Grande, followed by Niterói, Campos dos Goitacazes, Petrópolis and Limeira. In the Lake Region there are two private concessions serving eight municipalities associated with the state. Foreign private concessionaires, although with fewer concessions, have greater influence when the population with access is considered. In total, close to 3% of the urban Brazilian population reside in municipalities with services operated by private concessionaires.

The participation of private shareholders in some of Brazil's state sanitation companies such as Sanepar (Paraná) and Sanetins (Tocantins) should also be mentioned. In the first case, Grupo Dominó, led by the French company Vivendi and including Construtora Andrade Gutierrez, Banco Oportunidade and the state energy company Copel, owns 39% of the capital of the state company in Paraná. A shareholders' agreement defines participation in management, division of responsibilities and the decision-making process. In Tocantins, the private group Emsa initially acquired shareholder control of the company, which subsequently reverted to the state. All management is exercised by the firm's partners.

B. Mexico

Demographic trends in Mexico present tremendous drinking water supply and wastewater treatment challenges. Mexico's population is expected to increase from almost 105 million

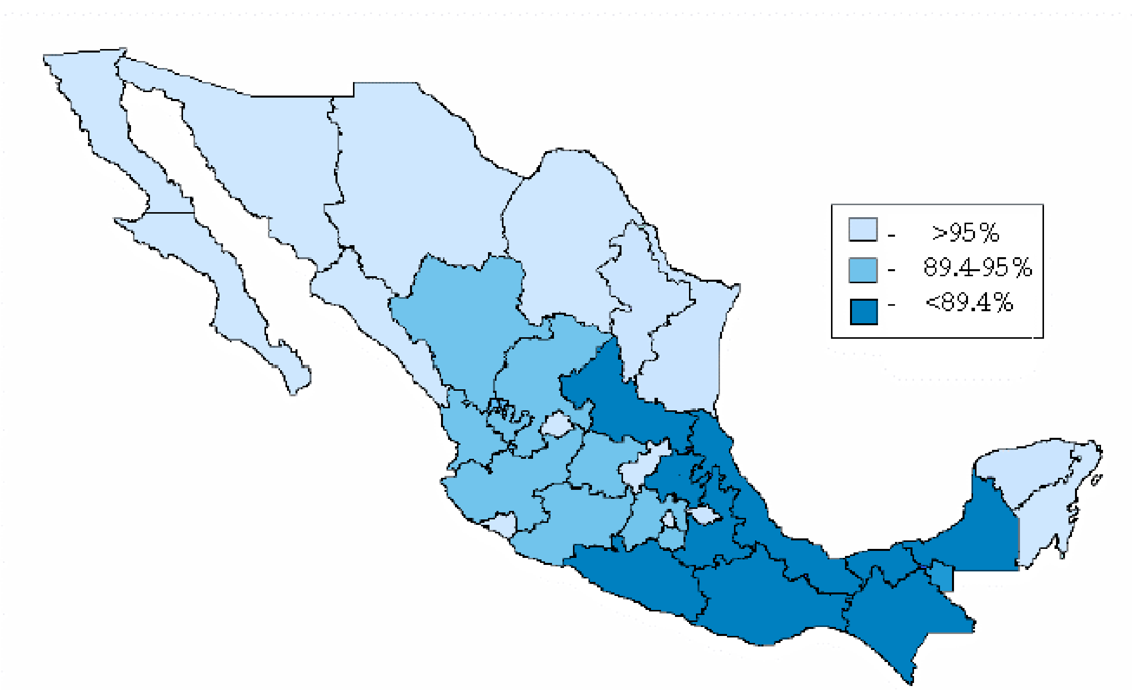
[6] Porto Alegre is the only Brazilian state capital whose services have always been performed by the municipality. In recent years the services in Rio Branco – AC, Campo Grande – MS, Cuiabá – MT and Manaus – AM were taken over by the municipality, while in Campo Grande and Manaus the services were conceded to private companies.

[7] Associação dos Serviços Municipais de Água e Esgotos (Association of Municipal Services of Water and Sewerage), original text in Portuguese, cited in PMSS, Modernization Series, Vol. 3.

in 2004, to 121 million by 2020.[8] There are approximately 200,000 towns across the country, of which 1.5% are urban, the remainder being rural. Around 80 million people are concentrated in urban areas.

In 2003, Mexico extracted 72.6 km^3 from surface and ground water resources, most of which was diverted to agriculture and livestock (77%), 13% to public and urban use, and 10% to industry (including services, businesses and thermoelectric plants). In public and urban use, 66% of source water is pulled from aquifers and 34% from surface water. It is estimated that of Mexico's total population, 89% have drinking water access (**Figure 1**) while 77% are connected to sewerage networks (**Figure 2**),[9] still leaving 12 million people in Mexico without access to water services and 24 million lacking access to sewerage networks.

Figure 1. Drinking Water Coverage in Mexico



Mexico has expanded its water service faster than the rate of population growth. From 1980 to 2002, the population grew by 34 million people, approximately 1.5 million per year, while the number of people with water service increased by 43 million, nearly 2 million people per year. During the same period wastewater collection has increased by 44 million people, slightly faster than the growth in drinking water.

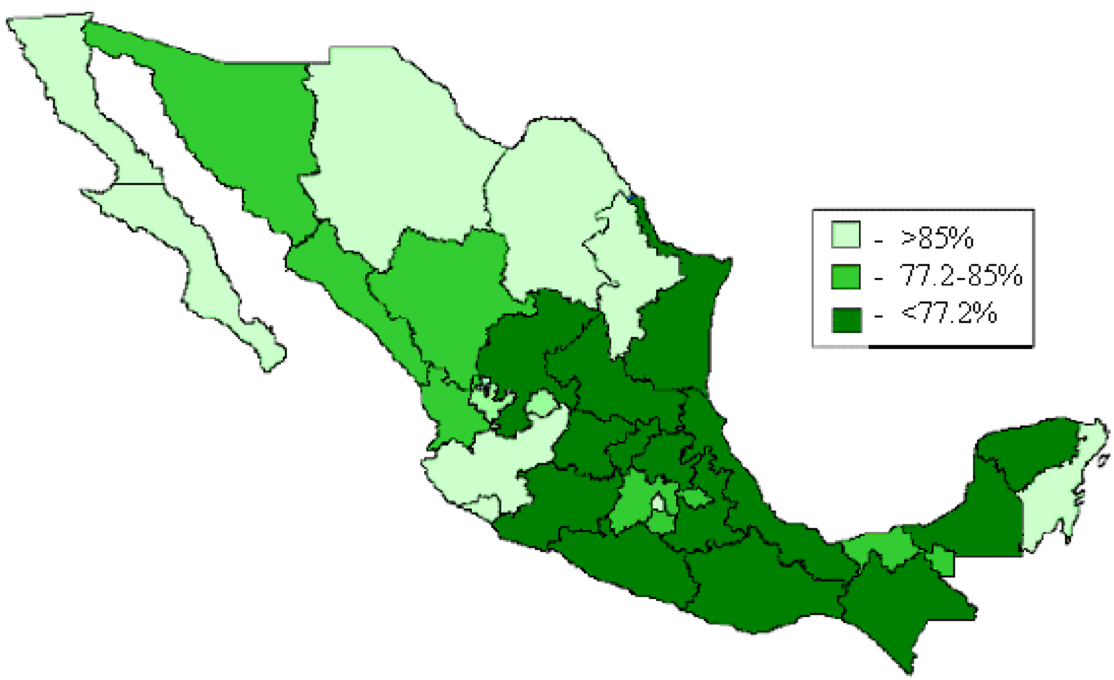
[8] Water Statistics in Mexico, (original text in Spanish: Estadísticas del Agua en México), National Water Commission (Comision Nacional del Agua), 2004.

[9] *Situation of the drinking water, wastewater and sanitation sub-sector as of December 2003*, (original text in Spanish: *Situación del subsector agua potable, alcantarillado y saneamiento a diciembre de 2003*), National Water Commission, 2004.

If only minimal investments in improving the efficiency of drinking water supply system continue, given the increasing population, annual water demand will grow 1.38 km^3 (43.75 m^3/s), meaning that water withdrawals will increase from 9.6 to 11 km^3. Of this, 7 km^3 (228 m^3/s) are expected to be extracted from groundwater wells and the remaining 4 km^3 (120 m^3/s) from surface water, which requires treatment prior to drinking. Investing in energy efficiency can reduce water demand at less than the cost of exploring new water sources.

Although the volume of wastewater collected in Mexico is quite high, the volume of wastewater *treated* in 2004 was only 30% because treatment infrastructure has lagged wastewater collection infrastructure.[10] By 2003, Mexico had 526 potable water treatment plants, with an installed capacity of 127 m^3/s. Of these plants, 465 operate, treating 83.7 m^3/s of surface water, only 66% of the installed capacity of the plants that are in operation. Therefore, if fully utilized, the plants would be sufficient to cover anticipated future demand in the year 2020. The most commonly used wastewater process (**Figure 3**) is conventional clarification, in use at half of the total surface water treatment facilities (231 plants).

Figure 2. Sanitation System Coverage in Mexico



[10] *Impact of modifications to the budget 2005, (*original text in Spanish*: Impacto de las modificaciones del presupuesto 2005),* presentation by Federal Deputy Leonel Vizcarra. Financing Forum for the Drinking Water Sector (Foro de Financiamiento para el Sector de Agua Potable) organized by ANEAS, November 2004.

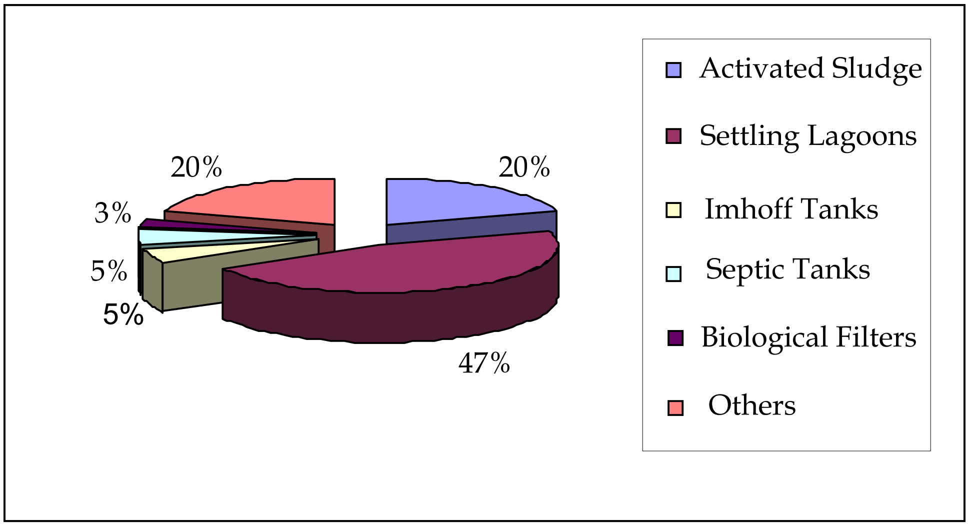


Figure 3. Wastewater Treatment Processes Used in Mexico

IV. The Role of Energy in the Water Sector

A. The Water-Energy Relationship

Energy costs dominate the cost of producing and supplying water production, exerting significant pressure on existing energy infrastructure in countries struggling to produce adequate supplies. Energy is used in the water sector in almost every process, from diversion, processing and distributing drinking water, to the operations needed to collect and treat wastewater. Every liter of water that passes through a system represents a significant energy cost. Water losses in the form of leaks, consumer theft and waste directly increase the amount of energy consumed to supply water. The production and supply of water to municipalities is energy-intensive not only because most of the operations involved require energy but because they are performed without interruption year-round. Water losses waste a lot of energy, making efficiency improvements in municipal water utilities worthwhile investments that return impressive yields in the form of operational and overhead savings, superior service, and improved financial sustainability. High variability in levels of water service provided throughout the world, geographic and topographic variability, source water availability and water system design characteristics all affect the energy consumed in the water sector. An overview of the role that energy plays in the water sector in Brazil and Mexico gives a sense of the scope of this relationship.

> Every liter of water that passes through a system represents a significant energy cost.

In contrast to much of the world, the Brazilian government collects and analyzes detailed data for the water sector that includes energy consumption. **Table 1** shows that the water and wastewater sector in Brazil, consumes 8.6 billion kWh/year, based on data collected

from utilities.[11] According to estimates by Eletrobrás in 1998, the Brazilian water and sanitation sector accounted for approximately 2.3% of the country's total electric energy use.[12] In 2003, net electricity consumption in Brazil was 352 billion kWh,[13] indicating an increase in energy use to 2.5% for this sector. In Mexico, water utilities have an even greater effect on overall energy consumption, with water utilities reporting energy consumption costs of approximately US$ 500 million per year, or 4% of Mexico's total electrical energy costs in 2003.[14],[15]

Table I. Energy Consumption by the Water Sector in Brazil

Energy Consumption by Sector				
REGION	**Water**	**Wastewater**	**Total Sector**	**Financial Impact**
	Energy Consumption (1,000 kWh/year)	Energy Consumption (1,000 kWh/year)	Energy Consumption (1,000 kWh/year)	Energy Expenditures (US$)
North	358,179	2,560	360,739	24,499,220
Northeast	1,713,617	83,326	1,798,943	111,561,108
Southeast	4,751,517	328,441	5,079,958	299,574,345
South	769,505	49,868	819,373	86,438,401
Centro-western	544,668	49,763	594,432	42,585,268
TOTAL	**8,137,486**	**515,958**	**8,653,444**	**564,658,341**

Measures taken to save water and energy can often have a major impact when planned in an integrated manner. For example, a leak reduction program alone may save water and reduce pressure losses, resulting in energy savings due to lower pumping demand.

[11] *National Sanitation Informaiton System,* (original text in Portuguese: *Sistema Nacional de Informações Sobre Saneamento)* (SNIS), Programa de Modernização do Setor de Saneamento (PMSS) (Sanitation Sector Modernization Program), Ministério de Cidades, 2003. Available online at http://www.snis.gov.br/

[12] *Procel Sanear Action Plan* (originl text in Portuguese: *Plano de Ação do Procel Sanear*), Eletrobras, p 11.

[13] Energy Information Administration (EIA), "Brazil Country Analysis Brief," August 2004. Available online at www.eia.doe.gov/emeu/cabs/brazil.html.

[14] Federal Energy Commission (*Comisión Federal de Electricidad*), *Statistics on the consumption and sales of energy in Mexico 2001-2003,* (original text in Spanish*: Estadisticas de consumo y ventas de energia electrica en Mexico 2001-2003*), Available at www.cfe.gob.mx.

[15]National Water Commission (CNA). "Efficient Use of Energy and Water in the Drinking Water Sub-sector," (original text in Spanish: "Uso Eficiente de Energia y Agua en el Susector de Agua Potable"), presentation by CNA's Research and Project Management Division at the First National Seminar on the Efficient Use of Water and Energy--Watergy in Boca del Rio, Veracruz, Mexico, 2003. Available at www.watergymex.org.

Replacing an inefficient pump with a more efficient model saves energy. If the two activities are coordinated through a water and energy efficiency program, the reduction in pressure losses from leaks will allow smaller pumps to be used for the same job, producing even more substantial savings.

The practice of implementing energy efficiency measures in water supply systems, a practice termed **Watergy** by the Alliance to Save Energy, provides the consumer with water services using the least amount of water and energy possible. The Watergy concept covers a wide spectrum of activities related to the efficient use of water and energy, and those activities resulting from the joint administration of these resources. Understanding the nexus between water and energy within a water supply system allows water utilities to tailor their policies and practices to improve efficiency. Tackling water and energy separately misses this opportunity.

> Watergy is an approach developed by the Alliance to Save Energy that helps cities manage water and wastewater efficiently, saving energy, water and money.

B. Energy Consumption in Water Utilities

The energy costs of a water utility typically represent a predominant portion of the utility's total operating costs. In order to address the impacts that energy costs have on a water utility, it is necessary to describe in detail the energy used by the main electromotor systems in the utility, such as pumping systems, blowers, fans, conveyor belts, agitators, and aerators. These systems are the major energy-consuming technologies in the water sector. **Table II** provides a summary of the electromotor systems in use at different stages of water and wastewater system operations, and demonstrates that pumping systems dominate the energy consumption of water utility operations. For this reason, a key component to water system efficiency is identifying the variables that affect energy consumption by pumping systems.

Table III lists the typical operations found within a water utility and their relative impacts on energy consumption. Source extraction can come with a very high energy cost, depending on the depth of the groundwater or the quality of the raw water. The impacts of transmission are highly variable because of variability in topography and system design. In distribution, the water that flows through the system embodies energy from all previous steps in the process. For example, leaks require more water to be pumped and encrusted pipes require more energy to pump the water.

Overall energy costs consume 32 to 40% of the gross revenues of Mexican and Brazilian utilities. This situation makes energy a vital factor in the efforts being made by utilities to improve their financial situation. The magnitude of potential energy savings documented in case studies—between 10 and 40%—is a meaningful boost to a water utility struggling to provide services. For example, one case study developed by the Alliance to Save Energy in Mexico incorporated efficiency into operations and maintenance and helped the utility reduce their energy bills by 24%, lowering energy intensity by 0.1 kWh/m^3.[16] More detail on this and two other case studies is provided in Section VII.

[16] Based on the unit cost of energy in US$/kWh as calculated by the Alliance to Save Energy in the development of case studies for the Watergy program in Mexico, available at www.watergymex.org.

Table II. Electromotor Systems Used in Operations of a Water Utility

STAGE	OPERATION	ELECTROMOTOR SYSTEM
DIVERSION	Deep well extraction	Submersible or Shaft Turbine Deep Well Pumping Systems
	Diversion from a surface source	Horizontal or Vertical Centrifugal Pumping Systems
TREATMENT	Disinfection	Piston-Type Dosing Pumps
	Treatment	Pumping Systems, Fans, Agitators, Centrifugal Blowers
PIPING	Sending the drinking water to the distribution grid	Submersible or Shaft Turbine Deep Well Pumping Systems Horizontal or Vertical Centrifugal Pumping Systems
	Booster Pumping	Horizontal or Vertical Centrifugal Pumping Systems
DISTRIBUTION	Storage	N/A
	Distribution	Horizontal or Vertical Centrifugal Pumping Systems
STORM AND SANITARY SEWER SYSTEMS	Diversion of Wastewater and Rainwater	N/A
	Storage of wastewater and/or rainwater	N/A
	Piping of Sewage and/or rainwater	Horizontal or Vertical Centrifugal Pumping Systems
	Wastewater Treatment and Disposal	Pumping Systems, Fans, Agitators, Centrifugal Blowers
OTHER OPERATIONS	Telemetry and Control	Lighting Systems and Electronic Equipment, Air Conditioning Systems, if applicable
	Additional Operations	

Table III. Energy Impacts on Typical Water and Wastewater Operations

Stage	Operation	Basic Description	Energy Impact (%)	Observation Regarding Energy Consumption
DIVERSION	Deep well extraction	Extract water to the surface by pumping raw water from a deep well	30-60	The energy cost depends on the depth of the well. Continual drawdown of an overexploited source can substantially affect this cost.
	Diversion from surface source	Impounding raw water from a river intake, spring or other surface source and pumping it to the treatment plant	0-10	This cost is relatively lower than that for deep well extraction. Energy indices in (kWh/m^3) tend to be up to 30% less[17]. This can vary greatly depending on distance and height pumped.
TREATMENT	Disinfec-tion	Dosing with chlorine or other process such as ozonation to achieve disinfection required by local regulations	1-2	Energy consumption of dosing is generally quantified during treatment or during the pumping of water from the deep wells
	Treatment to drinking water standards	Processing the raw water at a primary or secondary treatment plant	5-10	Surface water may contain a significant level of organic pollution and other kinds of contaminants that require treatment. Filtration and filtration backwash energy needs will depend on the level of treatment required.
TRANSMISSION	Trans-mission of water to distribu-tion network	Process of pumping the drinking water from the treatment plants to the network	0 - 40	Transmission is sometimes performed by gravity, which implies zero energy consumption. In cases where surface sources dominate, its impact may be very high.
	Booster Pumping	Pumping to areas with greater altitude from the regulating tanks, storage basins or directly from the grid.	5-35	Energy consumption in this operation depends on the topographical characteristics of the city, the original design of the grid and planning for future growth. In very flat cities, there is practically no impact

[17] Alliance to Save Energy. Case studies in Mexico. Available at www.watergymex.org/

Stage	Operation	Basic Description	Energy Impact (%)	Observation Regarding Energy Consumption
DISTRIBUTION	Storage	Operation and maintenance of storage tanks and basins in the system	NA	These activities may affect energy consumption but not directly. Water lost through leaks and energy dissipated in heavily encrusted mains are indirect consumers of transmission energy. Use of storage can reduce energy costs by shifting pumping loads to off-peak hours.
	Distribu-tion	Piping to transport water to customers, including maintenance of the network; leak detection, elimination; flushing of mains		
SEWAGE COLLECTION AND TREATMENT	Diversion of Waste-water and Rainwater	Maintenance and operation of sewage system and collection of wastewater	NA	This diversion is generally performed using gravity towards the basins
	Waste-water and Rainwater Storage	Maintenance and operation of the wastewater basins		
	Pumping of Sewage and/or Rainwater	Pumping of wastewater from the basins to the treatment plants or bodies of water	5-25	Energy consumption depends on collection coverage and pumping height from the treatment plants but is generally lower than the consumption for piping drinking water
	Treatment and disposal of Waste-water	Wastewater treatment processes to comply with local official regulations	0–45	The level of energy consumption of this operation depends on the levels of treatment coverage, on the amount and type of contaminants and the technology applied for treatment
OTHER OPERATIONS	Telemetry and Control		2-3	Proper automation of the system helps reduce energy costs.
	Addi-tional operations	All other activities such as administration, communication, etc.		Energy consumption from lighting, climate control in offices, control rooms and plug loads

V. The Case for Energy Efficiency: Cost of New Infrastructure versus Efficiency

A. Reassessing the Traditional Approach to Investment in Water Systems

Population growth and economic development demand a significant expansion in infrastructure for the supply and treatment of water. Investment costs to expand infrastructure depend proportionally not only on the growth in volume but on all aspects of energy flow in the system. Water and the energy to move it are finite resources that are increasingly strained by the growing demand for clean water.

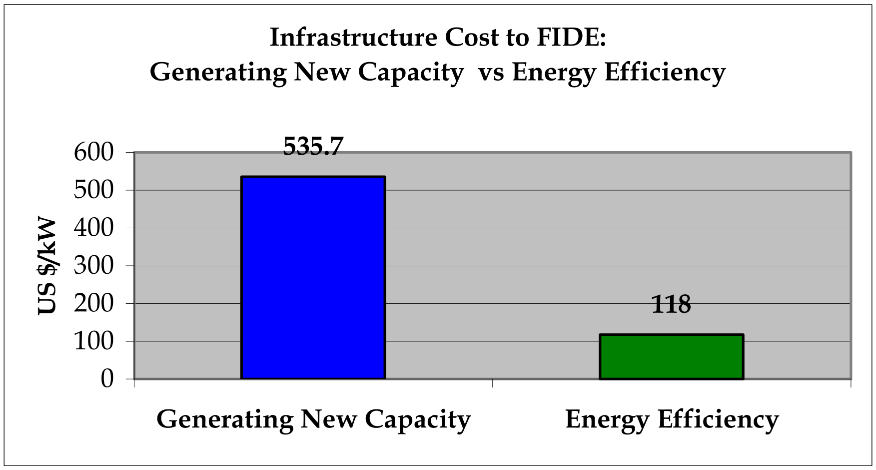
The approach traditionally taken to water infrastructure is to design systems that have a long time horizon and assume high growth in demand. Efficiency is not a factor, and procurement decisions are based on the lowest initial cost. Long time horizons and an assumption of rapid growth result in inaccurate estimates of demand 30 years down the road, leading to designs that are far oversized for shorter term needs. Oversized pump and motor systems are then throttled to operate at lower flows until the demand catches up, wasting energy because horsepower is constant. Also, throttled motors wear out more quickly and must be replaced after 15 or 20 years, never lasting long enough to serve the larger predicted demand for which they were purchased in the first place.

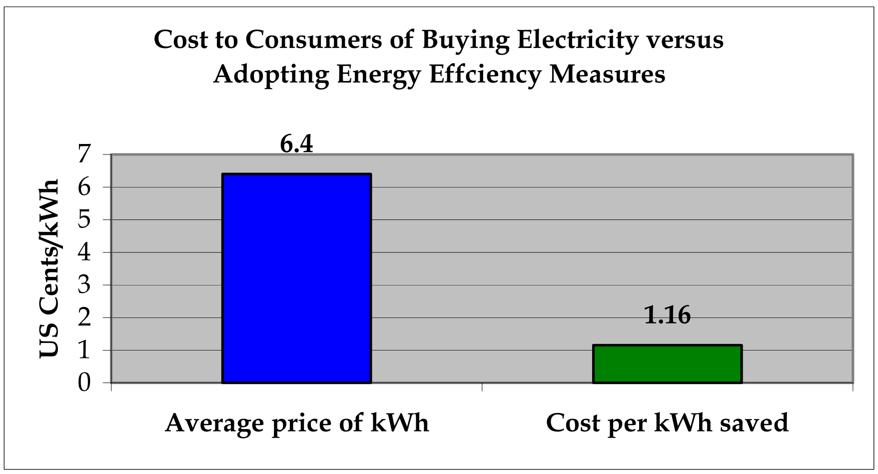
Water and wastewater investment decisions that neglect energy efficiency have a domino effect that increases investments in other sectors. For example, an estimated US$ 30 billion is required for new electric generating plants needed to power the new water infrastructure needed to serve the approximately two billion under-provided urban inhabitants expected around the world by 2025. Efficiency in water supply and wastewater treatment decreases the need for new power plants, as well as a wide range of other costs such as the social and operational costs of new power plants, operating expenses for water distribution and treatment, additional investments to extract and transport the additional fuel, and environmental costs due to emissions and declining water and hydrocarbon reserves.

Figure 4 illustrates the significant savings available in Mexico through efficiency measures, from installing new electricity capacity to end use by consumers. A study by FIDE (Fideicomiso para el Ahorro de Energia, the Government of Mexico Trust to Save Energy)—based on financial statements from Mexico's Federal Electricity Commission (CFE), the company that generates, transmits, and distributes electricity to a large part of Mexico—shows that efficiency measures are far less expensive than the costs of generating, distributing or buying electricity: [18]

- ✓ The cost to build *new generation capacity* is US$ 535,700 per MW, while the infrastructure costs to save one MW through efficiency is almost five times less expensive, around US$ 118,000.
- ✓ For a utility, the cost per kWh to *generate and distribute electricity* is US$ 6.60 whereas the cost involved in saving electricity through efficiency is only US$ 0.62.
- ✓ For *consumers*, the average price for a kWh of electricity is US 6.4¢, while the cost to save a kWh is only 1.16¢.

[18] Profitability study of energy saving investments in Mexico. *Fidecomisio para el Ahorra de Energia* (FIDE), 2003.





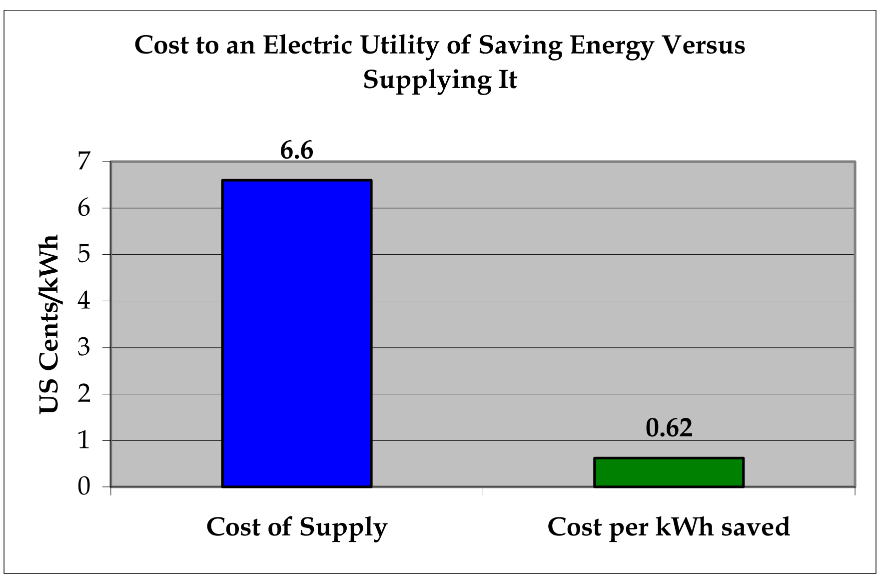


Figure 4. Cost Benefits of Energy Efficiency in Mexico

The case for energy efficiency is strengthened by high energy prices. In Mexico, for example, case studies performed by the Alliance to Save Energy Watergy program show that the mean energy price for some water utilities can be up to 9.3 US cents/kWh, 45% higher than the average electricity price in Mexico. [19]

B. Projected Costs for New Water and Sanitation Infrastructure

Many cities in Latin America and around the world are already struggling to provide adequate drinking water and sanitation to urban populations, and the expected doubling of such populations over the next 40 years will make the problem all the more severe. On a global basis, estimates indicate that current investment in water infrastructure around the world must double from its current level of US$ 75 billion per year in order to meet demand. This section describes two different estimates, by no means exhaustive, of the cost of new water infrastructure in Mexico and Brazil: one by the Inter-American Development Bank (IADB) and one based on Government of Mexico data.

> Investment decisions in the water and wastewater sectors that neglect energy efficiency have a domino effect that increases investments in other sectors.

Inter-American Development Bank Study

On a regional basis, an IADB study used the Millennium Development Goals[20] as a basis to estimate the investment in infrastructure needed for Latin America and the Caribbean. In the fifteen years from 2001 through 2015, the calculated costs would range from US$ 8.6 billion if only 25% were in-home domestic connections, to US$17.2 billion if 100% of the new connections were in-home connections.[21] (In Latin America and the Caribbean, construction of an in-home water connection costs four times more than provision of a standpipe within walking distance.) On an annual basis starting from 2001, this amounts to between US$ 573 million and US$ 1.15 billion every year for the region as a whole.

In order to estimate the investment in water infrastructure needed to meet Millennium Development Goals in Brazil and Mexico, the same IDB study assumed that projected urban growth implies a proportional need for additional in-home domestic water connections, while growth in populations of rural users means increases in hand pumps and standpipe-type connections. The resulting estimate of the water infrastructure investment needed to meet Millennium Development Goals from 2000 through to 2015 in Brazil and Mexico, including population growth, is: *US$ 5.4 billion for Brazil (US$ 362 million/year), and US$ 3.4 billion (US$ 227 million/year) for Mexico.*

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[19] Based on the unit energy cost calculated by the Alliance to Save Energy in the development of Watergy/Mexico case studies (www.watergymex.org/), and the Ministry of Energy document on the future of the electric sector 2004-2013 (www.sener.gob.mx/).

[20] The 2000 Millennium Development Goals, take the WHO data as a baseline and seek to halve the number of people without access to water and wastewater services by 2015.

[21] Inter-American Development Bank, *The Millennium Development Goals and the investment needs in Latin America and the Caribbean* (original text in Spanish: *La Metas del Milenio y las necesidades de inversión en América Latina y el Caribe*), Sustainable Development Department, October 2003.

NATIONAL WATER COMMISSION IN MEXICO

Another analysis of infrastructure investments for Mexico yields a mid-range estimate well over double this. This analysis uses the National Water Commission assumption the Mexican population will grow by an average of 1.03 million inhabitants per year from 2004 to reach 111 million inhabitants by 2010.[22] Considering a daily provision of 250 liters per person—a recommendation of the National Water Commission—about 91 million m^3 of water per year would be required for every million inhabitants. This equates to a need for an additional 93.7 million m^3 of drinking water per year to keep pace with population growth. **Table IV** provides the official Government of Mexico data for estimates of the infrastructure and operation costs needed for each cubic meter of water and sanitation (sewage collection and wastewater treatment). Using this data, a mid-range estimate for the cost of drinking water infrastructure is $US 2.80/$m^3$ (not including operations and maintenance), making the investment needed to keep pace with population growth about US$ 262 million (between US$ 112 and US$ 414 million) per year.

Table IV. Investment and Operation Costs for Water and Sanitation in Mexico[23]

INFRASTRUCTURE AND OPERATION COSTS		
CONCEPT	**Cost in US$/$m^3$**	
	MINIMUM	MAXIMUM
DRINKING WATER		
Investment	1.20	4.40
Operation and Maintenance	0.82	3.80
SUB-TOTAL	**2.02**	**8.20**
SEWAGE COLLECTION		
Investment	0.80	1.20
Operation and Maintenance	0.20	0.60
SUB-TOTAL	**1.00**	**1.80**
WASTEWATER TREATMENT		
Investment	0.60	1.30
Operation and Maintenance	0.40	1.10
SUB-TOTAL	**1.00**	**2.40**
INVESTMENT	**2.60**	**6.90**
OPERATION AND MAINTENANCE	**1.42**	**5.50**
TOTAL	**4.02**	**12.40**

[22] Water Statistics in Mexico (original text in Spanish: Estadísticas del Agua en México), National Water Commission (Comisión Nacional del Agua), 2004.

[23] Ochoa-Alejo L & Bourguett V, *Comprehensive Loss Reduction in Potable Water*, (original text in Spanish: *Reducción Integral de pérdidas de agua potable*), IMTA edition, Jiutepec, Morelos, México, 1988.

There is also a shortfall in access to drinking water today. If the goal is to reduce the shortfall to 10% by 2010, it will be necessary to supply 1.23 million additional inhabitants every year. Based on 250 liters/day and the mid-range cost estimate for drinking water investment from Table IV, 112 million m^3 of water a year would be required at a cost of about US$ 314 million annually. Therefore the combined cost of meeting population growth while bringing the lack of access to drinking water down to 10% would require about 206 million m^3 each year at a cost ranging from US$247 million to $906 million, or about *US$ 576 million per year for Mexico* using the mid-range estimate.

The two estimates described above differ because they are based on somewhat different timeframes, data sources and assumptions, but both place water infrastructure needs in the near future for Mexico and Brazil in the range of several hundred million US dollars per year each.

C. Adding Energy to Considerations of Water and Sanitation Infrastructure

A major oversight common to the development of new infrastructure is the failure to integrate energy costs into operations and maintenance budgeting. To provide water to the greatest number of people with the lowest drain on limited resources, efficiency measures must be incorporated into infrastructure planning in order to minimize the concomitant demands on energy, water and finances. The additional cost of energy, and the associated energy demand it implies, reveal a fundamental inconsistency in infrastructure planning, one that exerts even more pressure on an already struggling municipal sector. As new infrastructure is brought on-line, it is critical to future operational viability that this infrastructure make optimum use of efficiency opportunities, given the burden that the infrastructure places on financial and energy resources.

To understand the importance of energy costs in water infrastructure investments, we can estimate the costs for energy and energy infrastructure associated with the hydraulic infrastructure, including all sequences along the energy chain. Based on the average energy intensity of water supply of 0.6 kWh/m^3 for Mexico in the absence of efficiency measures, calculated by the Alliance to Save Energy,[24] the increase in energy consumption per year is about 124 GWh, using the 206 million m^3/year estimate for Mexico to keep pace with population growth and decrease the current shortfall to 10%. This would require an additional US$ 11.5 million a year in operating costs for the water utilities (at 9.3 cents/kWh).

With an additional US$ 8.2 million for the electric company to buy the additional energy from power plants, US$ 8.3 million to build new capacity, and US$ 8.3 million for investments in transmission and distribution, the energy infrastructure needed to support the additional water and sanitation services would cost an additional US$ 36 million per year. **Table V** summarizes mid-range estimates of the annual investment from 2004 to 2010 needed for new drinking water infrastructure in Mexico (based on the costs given in Table IV, not including operations and maintenance costs) and its associated energy needs.

[24] Alliance to Save Energy. Case studies in Mexico. Available at www.watergymex.org/.

Table V. Investment Needed for Additional Drinking Water Infrastructure in Mexico (Estimated Annual Investments between 2004 and 2010)

	Water Infrastructure (million US$/year)	**Additional Energy** (million US$/year)	**Total** (million US$/year)
For Population Growth	262	16	279
To Reduce Shortfall to 10%	314	20	334
Total	576	36	**612**

Although this paper does not focus on wastewater, it is worth noting that wastewater treatment is also a large energy sink. In one case study developed by the Alliance in Mexico,[25] the overall energy intensity of the utility was calculated at 0.48 kWh/m^3 with a minor contribution from the water treatment system of 0.03 kWh/m^3. The system was treating a total of only 8% of the total wastewater being generated. However it was estimated that expanding the utility's wastewater services to 100% would nearly double the utility's energy intensity to 0.89 kWh/m^3. This clearly demonstrates the impact of expansion of wastewater infrastructure on energy consumption.

Environmental Strain

In addition to the monetary burden of inefficiency, the added fossil fuel combustion exacts a significant environmental cost. In Mexico, for example, every GWh consumed produces on average 1,263,000 tons of CO_2, 17,240 tons of SO_2, 1,062 tons of particulates, 3,480 tons of NO_2 and 170 tons of hydrocarbons. The added 124 GWh in energy per year to support additional drinking water infrastructure through 2010, and 530 GWh for additional wastewater treatment in 2005 would pollute Mexico's air every year with an additional:

- 153 million tons of CO_2
- 2 million tons of SO_2
- 432,000 tons of NO_2
- 132,000 tons of particulates
- 21,000 tons of hydrocarbons

D. Costs and Benefits of Energy Efficiency

Case studies developed by the Alliance to Save Energy in Mexico, Brazil and other parts of the world as part of its Watergy program[26] have shown that low cost, high benefit investments are recovered in less than two years through energy savings. Water recovery and leak reductions are also highly profitable and beneficial, as demonstrated in Section VI.D. In Mexico, for example, the water currently lost to leaks would cover the expected growth in water demand there for the next six years, meeting future needs and diminishing

[25] Based on the unit energy cost calculated by the Alliance to Save Energy in the development of Watergy/Mexico case studies (www.watergymex.org/),

[26] Alliance to Save Energy. Case studies available at www.watergymex.org and www.watergy.org/

current shortfalls so that investments in infrastructure could be postponed. The estimated investment needed for flow recovery to 85% efficiency is US$ 0.076/m^3 according to studies by the Mexican Institute of Technology (IMTA). Alliance case studies have shown that typical energy efficiency measures result in energy savings of 10% to 40%, with payback periods ranging from immediate to two years.

Table VI shows estimates for the potential energy and cost savings of energy efficiency, and the cost of implementing these measures. Costs for efficiency investments are estimated as:

$$E_W \bullet (\$/kWh) \bullet Savings \bullet Payback$$

where

- E_W is the total energy consumed by a given country's water sector. It was calculated as 4% and 2.5%, for Mexico and Brazil respectively as described in Section IV.A, of each country's total electricity consumption (from the U.S. Energy Information Administration for 2002).
- $/kWh is the average cost for electricity paid by water utilities: US$ 0.093/kWh in Mexico (Section V.A) and US$ 0.06/kWh in Brazil (Table IX).
- Savings is the potential energy savings from efficiency measures taken in the water sector, conservatively assumed for this calculation to be 20%.
- Payback is the time needed for energy savings to repay the cost of efficiency investments, assumed for purposes of this calculation to be an average of one year.

Using these parameters, the total potential cost savings due to efficiency accrued by the water sector in Mexico and Brazil over a ten year period—a relatively short planning horizon in the water industry—is estimated to be US$ 2.35 billion, from an initial investment of US$ 261 million. These figures are not discounted over time nor do they include inflation. The point is not the absolute magnitude of these figures, which are extremely high because they assume that serious attempts are made to improve efficiency over the *entire* water sector in both countries. The message is the relationship between the efficiency investment and the resulting return on investment: *these estimates find that, based on multiple case studies, the average annual rate of return on an efficiency investment in the water sector in Brazil or Mexico over a ten-year period is roughly 80%. In other words, every dollar invested to save water and energy returns on average NINE dollars.*

Table VI. Costs and Net Savings of Energy Efficiency in the Brazilian and Mexican Water Sectors, Assuming an Average One-Year Payback Period

	Cost of Investment (Million US$)	Net Savings (million US$)	
		Over 2 years	Over 10 years
Mexico	139	139	1,250
Brazil	122	122	1,102
Total	**261**	**261**	**2,352**

This analysis demonstrates the significant revenue stream available through efficiency, revenue that can be invested back into the sector to make further operational improvements and to pay for infrastructure needed to meet growing supply and demand needs. These estimates will vary considerably depending on the types of efficiency measures adopted, since investments for large-scale installation of efficient technologies must be assessed on a case-by-case basis. Yet even with a conservative estimate of 20% efficiency gains and a one year average payback period, the case for energy efficiency in the water sector is clear. Energy cost savings generated from efficiency measures more than pay for themselves and reduce the total investments needed for new infrastructure.

Table VII. Costs versus Benefits of Energy Efficiency in the Brazilian and Mexican Water Sectors

		Cost of Investment (Million US$)			Net Savings (Million US$)					
					Over 2 years			Over 10 years		
Savings Rate \ Payback (Yrs)		0.5	1	1.5	0.5	1	1.5	0.5	1	1.5
Mexico	18%	63	125	188	188	125	63	1,188	1,125	1,063
	20%	69	139	208	208	139	69	1,320	1,250	1,181
	32%	111	222	333	333	222	111	2,111	2,000	1,889
Brazil	18%	55	110	165	165	110	55	1,047	992	937
	20%	61	122	184	184	122	61	1,163	1,102	1,041
	32%	98	196	294	294	196	98	1,861	1,763	1,665
Total	18%	118	235	354	353	235	119	2,235	2,117	2,001
	20%	131	261	394	393	261	132	2,483	2,352	2,223
	32%	209	418	629	628	418	211	3,973	3,764	3,556

Table VII provides the data for the low efficiency, mid-range efficiency and high efficiency gains that were obtained in the case studies. Based on this data, **Figure 5** and **Figure 6** illustrate three cost curves of these gains separately for Mexico and Brazil. Payback periods of 6 months, one 12 months and 18 months were assumed. Savings are given over ten years. Based on the data available, an increase in investment leads to an increase in savings.

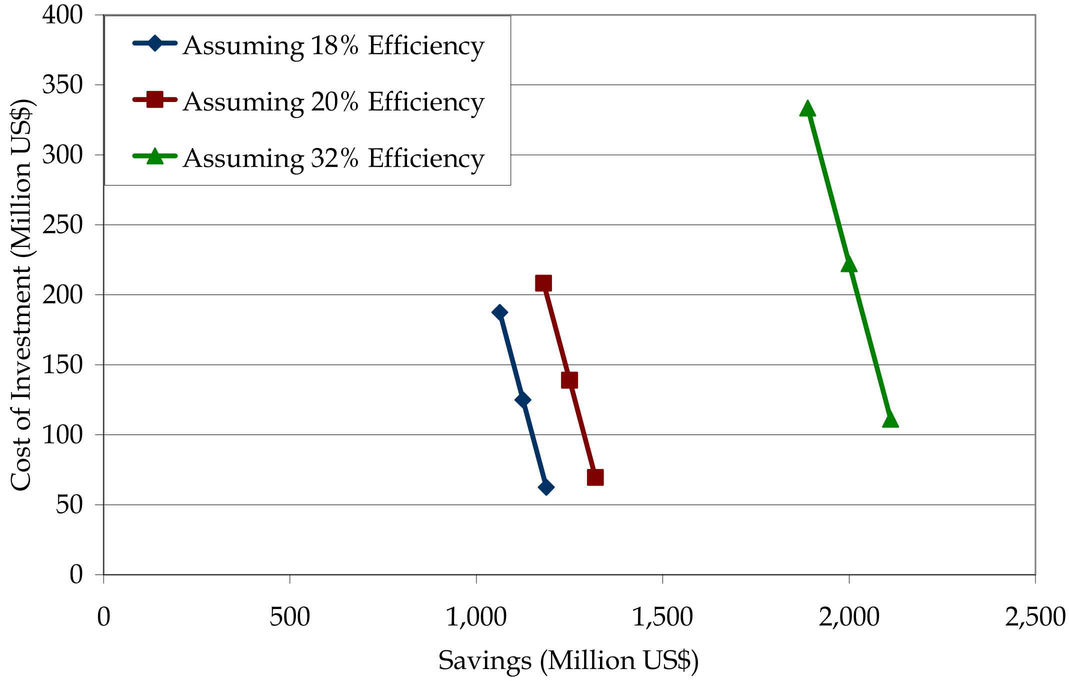

Figure 5. Costs Versus Benefits (Shown as Net Savings) of Energy Efficiency in the Mexican Water Sector

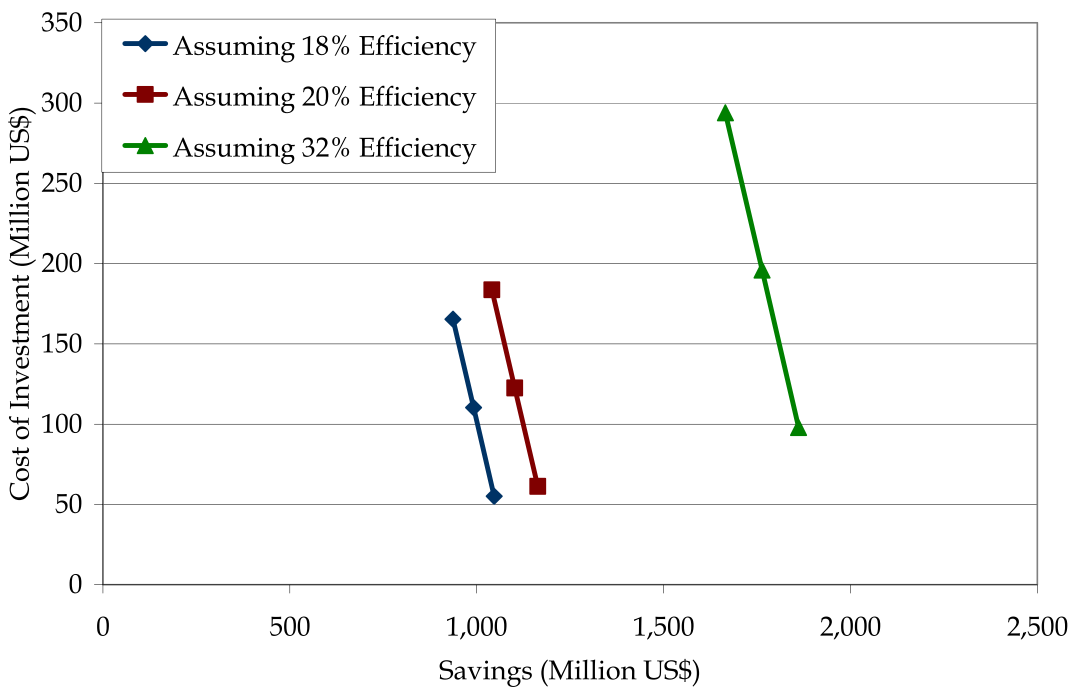

Figure 6. Costs Versus Benefit (Shown as Net Savings) of Energy Efficiency in the Brazilian Water Sector

VI. Achieving High Energy and Water Efficiency

Energy efficiency is defined as providing permanent reductions in energy use while maintaining equal or greater output, whatever that output may be, such as a unit of production; quality of service, such as space heating; or the generation of electricity. Energy efficiency practices and policies can be summarized into the following categories:

- Integrated resource planning – the practices that aid energy planners and regulators in evaluating the costs and benefits of supply (generation) and demand (end consumer), such that the energy used by the system poses the least financial and environmental cost.

- Efficiency in generation, transmission and distribution – the practices and technologies that stimulate efficiency in all electricity generated and delivered to end consumers. This category includes co-generation and natural gas-fired turbines, as well as other technologies capable of availing a larger quantity of electricity at existing plants.

- Demand-side management – the practices and policies adopted by energy planners that encourage consumers to use energy in a more efficient manner, as well as allowing administration of concessionaires' load curve.

- End-use efficiency – the technologies and practices that stimulate energy efficiency at the level of the end consumer. This category includes practically all the existing uses of electricity and calorific technologies, such as motors, illumination, heating, ventilation, and air conditioning, among others. It also includes technologies that encourage conservation and better energy use, such as solar energy generators and energy consumption control devices.

The most convincing advantage of energy efficiency is that it is always cheaper than energy production. Of course investment in efficient technologies for various end uses will also require greater capital expenditure, and efficient systems and equipment are generally more expensive than the technologies that they substitute. In addition, in many applications, the cost of energy efficiency corresponds to just one small parcel of the costs of energy production. Traditionally, these costs are handled by different agents and then charged to the consumer, the energy company, or the government.

Often the most tangible benefits of improving energy efficiency—financial savings on operation and maintenance costs of municipal utilities—are felt first at the local level: in towns, schools, hospitals, local businesses, and homes. Depending on the physical state of a municipal water system, municipalities can improve the reliability, quality and affordability of water supply and sanitation through efficiency measures rather than costly, high-investment new construction. Such measures include: improved management of operations and resources, better maintenance and leak detection, technological retrofits of pumping and distribution lines, as well as end-use installations.

> Water sector efficiency leaves more funds for crucial and often underfunded public services.

It is often the case in developing counties, including Mexico and Brazil, that the budget given to water utilities comes from a finite source of funds that also pay for priorities in the public domain, such as education, public health, environmental protection, community development, and local business development. Water sector efficiency leaves more funds for crucial and often underfunded public services. Case studies presented in Section VII provide real life examples of how municipalities have benefited from taking the least-cost energy efficiency route to address local resource needs. Greater awareness of their experience, combined with policies that facilitate more energy efficient resource use, can make cases like these more commonplace.

A. The Watergy Approach

The Alliance to Save Energy's Watergy program provides an integrated approach for gathering stakeholder input and producing and measuring energy savings. Savings realized from energy efficiency can then be redirected to other areas of operations and capital improvements. Often, infrastructure improvements can be justified based on the resulting energy savings. Watergy (a word coined by the Alliance to describe the interrelatedness of water and energy) is a program focused on providing utilities with the tools to estimate these savings. With 28 years experience working cooperatively with utilities in the U.S. and abroad, the Alliance has been identifying opportunities to save energy in water and wastewater systems operation in developing countries for over a decade.

> A key component to water system efficiency is identifying the variables that affect the energy consumption of pumping systems.

The Alliance works with local partners in the developing world and countries in transition to establish replicable energy efficiency policies and initiatives. Working at all levels—local, state and national—the Alliance strives to implement results-oriented projects and build host country capacity to develop and carry out their own energy efficiency initiatives. Starting in Ahmedabad, India in 1996, the Watergy program has spread to Eastern Europe, Africa, and the Americas, as well as to other locations in Asia. The program is now active in India, Mexico, Brazil, Philippines, Sri Lanka, South Africa, and has recently completed activities in Bosnia, Montenegro and Ukraine.

Because water pumping is such a large energy cost for cities, the Alliance developed specialized expertise in this area, including a Watergy training manual and toolkit for municipalities. The manual is now available in English, Spanish, Portuguese, Russian, and Bosnian, and covers topics such as supply-side efficiency, demand-side improvements, strategies for organizing Watergy teams, water conservation, leak detection, and financing.

All Alliance interventions are tailored to the local context, so activities have varied by location depending on need, the policy environment, and local expertise. This is illustrated by the range of results the program has produced, a few of which include:

- ✓ leak detection training for more than a dozen cities in Bosnia & Herzegovina and Montenegro, resulting in an estimated water savings of more than 540 million gallons per year;
- ✓ capacity building in state-level urban development agencies in India to assist local governments with energy efficiency;

- ✓ a lease-finance program for pump retrofits developed for Ukrainian water utilities;
- ✓ water pre-payment and performance contracting in water utilities in South Africa; and
- ✓ peak energy use reduction in Ahmedabad, India from 36 to 32 MW (11%), saving approximately $21,000 per year, and capacitors used to increase pump efficiency, saving more than one million kWh for a value of approximately $60,000 per year.

B. Existing Efficiency Initiatives in the Water Sectors of Mexico and Brazil

MEXICO

In Mexico, there are various efforts focused on promoting and financing energy saving projects. In 1989, the National Energy Savings Commission (CONAE) and the Trust to Save Energy (FIDE) were created. The purpose of CONAE, which falls under the Mexican Ministry of Energy, is to coordinate efforts in energy efficiency across sectors. It promotes energy efficiency in the municipal sector through a s program coordinated with the Federal Energy Commission (CFE), FIDE and the National Development Bank of Public Works and Services (BANOBRAS). These institutions support efficiency projects in public buildings, public lighting systems and municipal potable water utilities. With this shared objective the two institutions worked together to create the Program for Energy Efficiency in Municipalities, a program that provides assistance to municipalities to undertake energy audits and obtain financing to implement measures that require external resources. The amount of financial support provided by FIDE is about US$ 50,000 per municipality and includes no financing costs. The amount provided by BANOBRAS can reach US$ 250,000 with financing costs and processing problems that are preventing them from being accessible to municipalities.

IMTA, an institution that has been involved in the development of water treatment technology for the past thirty years, is making the most visible technical effort to encourage greater water efficiency and overall efficiency of water management. The financial resources supporting these efforts have come from Mexico's National Water Commission.

The Alliance began providing technical assistance for Mexican water and wastewater utilities in 2003, with support from the U.S. Agency for International Development (USAID). Partnerships have been forged with two municipal water utility partners: the Metropolitan Potable Water and Sanitation System (SAS) in Veracruz and the water utility of Oaxaca City, ADOSAPACO. The Alliance trained staff from both utilities, strengthening their ability to identify and realize energy and water savings within their systems. The resulting Watergy pilot projects demonstrated that it is possible to improve service conditions and increase access to water while maintaining or reducing energy costs and water losses. Energy savings at SAS, for example, were 24%. The Mexico Watergy program will continue to spread knowledge and develop partnerships that can lead to improved efficiency within water utilities throughout Mexico, especially in the United States-Mexico border region where water and energy pressures are acutely felt and there is great potential for international technical exchange. The Alliance developed two case studies from this work

to illustrate the benefits of water system efficiency to utilities around the country (see Section VII.B and VII.C).

BRAZIL

In 1985, the Brazilian federal government began to consider a strategy for promoting energy conservation and the then-named "National Program for Electricity Conservation" was instituted. Today this effort is know as the "Program to Promote Energy Conservation" (*Programa Nacional de Conservação de Energia Elétrica* (PROCEL), program of the Ministry of Mines and Energy that focuses on energy efficiency. The PROCEL Sanear program focuses specifically on the water sector, stressing training and information dissemination rather than helping to secure project financing. In 1994, the program went through a process of revitalization, including an effort to take advantage of the advancement of international institutions, which could be obtained through agreements with the European Community, U.S., and Canada. It was widely understood that the energy efficiency programs adopted in those countries had, in addition to a solid technological base, a strong orientation towards the market. This required that a new approach be adopted in Brazil towards consumer needs, expectations and behavior.

PROCEL began to establish a variety of agreements with energy concessionaires, municipalities, state governments, development agencies, regulatory agencies and relevant associations, in order to create a network of partnerships throughout Brazil. Through this network PROCEL has undertaken an important initiative towards technological, regulatory and educational development to advance energy efficiency across the country.

PROCEL's efficiency programs that focused on the water and sanitation sectors encompass the collection, treatment, transportation and distribution of water, as well as activities critical to sewerage. The sanitation sector has a regionalized structure based on state companies and municipal services, but does not have institutional or management support at the national level that allows technical and operational modeling capable of disseminating relevant technological developments. Thus, the energy efficiency approach for the Brazilian sanitation sector must correspond and take into account the sector's technological lag due largely to lack of investment.

In general, sanitation companies only apply energy efficiency activities to energy demand, which adds fines to energy bills that exceed the contracted demand. PROCEL's goal is to reduce electricity waste in the sector by 15% with the adoption of actions that seek:

- Load modulation in relation to the peak load of electricity systems
- Control of reservoir drainage in relation to the demand on the distribution network
- Appropriate sizing or resizing of electro-mechanical equipment
- Automatic operation of systems with real-time management and supervision.

PROCEL has implemented pilot projects, often in partnership with the Canadian government, using demonstrations to encourage efficiency in the following utilities:

- COMPESA – Utility Serving the metropolitan region of Recife
- COSAMA – Utility Serving the city of Manaus

- EMBASA – Utility Serving the state of Bahia
- CAEMA – Utility Serving the city of São Luiz
- Sanesul – Wastewater Utility in the state of Mato Grosso do Sul

Through PROCEL, Eletrobrás—the national energy company of Brazil—has supported energy efficiency actions in the environmental sanitation sector since 1996. As of 2003, in partnership with the National Secretary of Environmental Sanitation of the Ministry of Cities, work has been developed with the intent of articulating actions seeking synergy among sectors: energy, environmental sanitation, environment and health. In this context, the PROCEL project Sanear was created, a project that seeks to select demonstration projects in public water supply systems that result in reduced peak demand, electricity and water use.

The equalization of pressure within water supply networks, one of many measures advocated within the water and energy efficiency approach, allows a utility to serve a greater number of people with little or no increase in water input.

Another positive benefit resulting from an energy efficiency focus directed at water utilities is the associated conservation of water resources. The equalization of pressure within water supply networks, one of many measures advocated within the water and energy efficiency approach, allows a utility to serve a greater number of people with little or no increase in water input. PROCEL also has programs in public lighting, demand-side management, public buildings, education, electricity system losses, municipal energy management, regulation, the industrial sector and consumer marketing.

The Alliance to Save Energy, supported by USAID, began a Watergy program in Brazil's northeast in 2001 in partnership with the Ceará state water utility, CAGECE. The focus of the partnership has centered on developing CAGECE's capacity to implement energy efficiency measures, while simultaneously reducing costs, decreasing environmental impacts and improving water delivery. Since that time, the Alliance has helped establish a network of the country's state- and-municipally operated water and wastewater utilities. This network, the Brazilian Water Efficiency Network (ABAE), is addressing the tremendous efficiency opportunities present in Brazil's water and wastewater sector, linking efficiency efforts of the sector, and serving as a forum to share experiences and develop a more comprehensive approach to energy efficiency nationally. A case study of the Watergy program in Fortaleza, Brazil is given in Section VII.A.

C. Technologies and Utility Practices

Typical measures to save energy and some technologies that help water utilities reach this end aim to comply with functions such as:

- Controlling and optimizing variables that affect the power of the pumping systems, the flow that is supplied (and lost) and the electromechanical efficiency. The total load supported by the pumping system is a more complex variable that depends on natural and topographical factors, but that can also be modified or optimized using hydraulic modeling and flow and pressure isolation zoning techniques.

- Optimizing the operating times of equipment, combined with the power of the pumping systems results in energy consumption, measured in kWh, and represents one of the main components of the energy bill of water utilities.
- Automating energy resource management and other operations and maintenance activities that influence a water utility's energy bill can provide utilities with a planning tool and a maintenance warning system if energy rates, hours of consumption, and other parameters are tracked and compared to a baseline amount each month.

A summary of typical measures to save energy is shown in **Table VIII**.

D. Energy Lost to Leaks

OVERVIEW

Every liter lost from a leak in the supply system is compounded by the money invested to produce it.

A drinking water system consumes energy largely due to the use of pumping equipment. When this equipment becomes worn by continuous usage, its performance is reduced and therefore the consumption of energy increases. It is then necessary to either replace or repair this equipment.

Nevertheless, there are other factors that cause excessive consumption of energy. The internal deterioration of the pipes through which the pumped water is carried is caused by aging as well as changing pressure and flow conditions. As a consequence, the internal roughness of the pipes increases, increasing the dynamic operating load of the pumps and therefore increasing energy consumption.

Another factor that leads to energy waste is water losses. These increase water demand, which is reflected by a greater pumping flow and therefore a higher consumption of energy. Secondly, a large amount of water that has been pumped is wasted due to leaks. In general, nobody uses the water lost from the leaks, which means a loss of money for the utility and water shortage for the municipality's inhabitants. From a single leak, flows can be lost ranging from 20 milliliters a second (mL/s) from water fittings to 250 mL/s from main pipes and valve boxes. Every liter lost from a leak in the supply system is compounded by the money invested to produce it, or in other words, the cost of the energy used to pump it and the chlorine that was injected to make it fit for drinking.

Table VIII. Technologies and Practices to Achieve Energy and Water Efficiency

<table>
<tr><th>Aspect</th><th>Energy Saving Technology or Practice</th><th colspan="2">Function</th><th>Typical Payback Period (years)</th></tr>
<tr><td rowspan="5">Energy supply</td><td rowspan="3">Management of electricity rates</td><td colspan="2">Self-Generation of Electricity during Peak Hours</td><td>1.5-2.5</td></tr>
<tr><td colspan="2">Adjusting Electricity Rates to Most advantageous (in Mexico, 06 rate to OM rate)</td><td>0- 0.1</td></tr>
<tr><td colspan="2">Demand Control at Peak Hours</td><td>0 – 2 depending on the storage capacity</td></tr>
<tr><td rowspan="2">Adaptation of electric installations</td><td colspan="2">Optimization of the Power Factor</td><td>0.8- 1.5</td></tr>
<tr><td colspan="2">Reduction in voltage unbalance</td><td>1 – 1.5</td></tr>
<tr><td rowspan="2">Maintenance and operational policies</td><td rowspan="2"></td><td colspan="2">Avoid and correct the over-sizing of substations</td><td>2 - 3</td></tr>
<tr><td colspan="2">Deep well maintenance and rehabilitation program</td><td>1 -2 it implies in some case more water availability</td></tr>
<tr><td rowspan="5">Technological improvement on the supply side</td><td rowspan="2">Production and pumping</td><td colspan="2">Avoid the unnecessary operation of pumping equipment</td><td>0 – 1 it implies level automatic controls</td></tr>
<tr><td colspan="2">To optimize the electromechanical efficiencies of the pumping systems</td><td>0.5 – 1.5</td></tr>
<tr><td rowspan="3">Distribution system</td><td colspan="2">Use of highly efficient motors</td><td>2 -3</td></tr>
<tr><td colspan="2">Redesign of the grid</td><td>2-3</td></tr>
<tr><td>Control of pressure and output in the networks</td><td rowspan="2">Sectoring;
Use of variable speed drives;
Installation of regulating valves</td><td>1.5-3</td></tr>
<tr><td rowspan="4">Technological improvement on the demand side</td><td rowspan="4"></td><td>Flow recovery program</td><td></td></tr>
<tr><td colspan="2">Incentive program for the use of efficiency technologies</td><td>1 - 3</td></tr>
<tr><td colspan="2">Effective macro- and micro-metering systems</td><td>1 - 2</td></tr>
<tr><td colspan="2">Low-consumption technologies in Wastewater treatment plant</td><td>1 - 2</td></tr>
</table>

In Mexico, the volume of the leaks average around 37% of the water entering the drinking water system.[27] In Brazil and Sweden the number is closer to 25%, and in Malaysia it reaches 40%.[28] Less than 15% is considered ideal, though some cities, such as the City of Austin, have reduced water losses in the system to 10%.[29] Leakage levels can vary greatly, however, and there is some concern that percent lost per unit volume is not an ideal indicator of utility performance. An alternative indicator, the Infrastructure Leakage Index (ILI) has been adopted by the International Water Association to describe water loss rates in utilities.[30]

The results obtained in Mexico—which are considered very similar to those occurring in most Latin American cities—show that more than one-third of the volume of water supplied is lost before the cost of the water can be recovered. Also lost are the energy and cost of energy embodied in that water, from pumping, treating and conveying the water.

In drinking water distribution systems, leaks commonly occur in water fittings, valve boxes, storage and regulation tanks, and in pipes that make up the water distribution system. In the Mexican drinking water distribution systems, between 80% and 90% of leaks occur in water fittings and the remaining 10 to 20% occur in distribution pipes. These leaks are mainly due to bad quality of materials, poor construction and disregard for current regulations. Leaks occur due to a variety of factors, including:

- High water pressure inside the pipe.
- External corrosion on metal pipes due to contact with the ground.
- Internal corrosion due to poor quality water carried inside the pipe.
- The passage of heavy vehicles over pipes located at shallow depth.
- Poor quality of materials and pipe accessories.
- Poor quality of labor used to install or repair the pipes.
- Very old pipes.
- Land movements (earthquakes).

Leaks produce many problems other than wasted water, for example:

- **Water pollution** caused by dirty water, roots or soil entering when the pressure drops or when the pipe is emptied.
- Increased **energy consumption** because the escaping water has to be pumped and greater pressure is required for it to reach the most distant places of the grid.

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[27] Arreguín-Cortés F. and Ochoa-Alejo L., 1997, Evaluation of Water Losses in Distribution Networks, Journal of Water Resources Planning and Management, ASCE, Sep-Oct, USA.

[28] Water Statistics in Mexico, (original text in Spanish: Estadísticas del Agua en México), National Water Commission (Comision Nacional del Agua), 2004

[29] City of Austin, Leak Detection and Repair, http://www.ci.austin.tx.us/watercon/leaks.htm, Accessed March 2005.

[30] AWWA Water Loss Control Committee, "Committee Report: Applying worldwide BMPs in water loss control," *Journal AWWA*, August 2003, pp 65-79.

- Increased **chlorine consumption** as chlorine is lost with water and also because leaks can introduce contaminants to the water that bond with chlorine and disable its disinfectant properties. Additional chlorine is then required to maintain the available chlorine residual at a level that safeguards public health
- Poor **institutional image** due to the fact that the utility is charging for a water service with many faults.
- Increased **infrastructure risk** since as the pipes or valves start to fail, their structure becomes worn and weakened.

In short, repairing leaks on time reduces:

- ✓ Water waste
- ✓ Energy use
- ✓ Chlorine expenses
- ✓ Expenses from overhauls.

Water currently lost to leaks in Mexico would cover the expected growth in demand there for the next six years, meeting future needs and diminishing current shortfalls so that investments in infrastructure could be postponed.

MEXICO

Leaks in Mexico were evaluated using a statistical method developed in 1990 and tested in more than 15 cities. With this method it is possible to estimate, with sufficient accuracy and reliability, the amount of water lost due to leaks existing in the distribution system, distinguishing between water fittings and pipes, and also the physical and operating variables associated with these leaks. During the development of the technique, 15 studies of this nature were performed; later, companies and government institutions conducted several more studies. The Mexico City case was also conducted in 1995 by a consulting firm, which, due to its complexity, deserves special attention.

The results of the first fifteen cities showed that, in general terms, the highest percentage of losses occurs in water fittings due to the aforementioned causes, but in cases such as the cities of Chihuahua, Tapachula and Veracruz, the problem in the main and secondary pipes is made worse by the age of the grid (more than 40 years). Some of these results are summarized in **Table VIX**.

The percentage of water that is produced and then subject to loss in a drinking water system is alarming. *The results obtained in Mexico – which are considered very similar to those occurring in most Latin American countries – show that more than one-third of the volume of water supplied is lost before the cost of the water can be recovered. Additional losses include the energy and its costs embodied in that water from pumping, treating and conveying the water throughout the distribution system.*

If the current efficiency of 65% is maintained, approximately 3,731 million m^3 will be lost in leaks. At a production cost of US$ 0.3/m^3 from diversion alone, US$ 1.12 billion would be wasted. This volume of water would require an energy consumption of 2240 GWh, resulting in an additional US$ 210.5 million wasted. If efficiency is increased to 85% (a technically desirable level) by the year 2010, US$ 120 million could be saved just from the energy wasted, 1,280 GWh, in the water that is lost to leaks.

Table VIX. Results from Water Loss Studies in Mexico

City	Flow Supplied (liter/second)	Losses in Fittings (%)	Losses in Pipes (%)	Losses in Fittings & Pipes (%)
Campeche, Campeche	525	29.7	21.7	51.4
Cuidad Del Carmen, Campeche	268	30.3	10.3	40.5
Chetumal, Quintana Roo	583	35.7	19.7	55.4
Fresnillo, Sonora	314	16.6	26	42.5
Leon, Guanajuato	3,045	21	32.4	53.1
Mazatlan, Sinaloa	1,350	15.2	18.6	33.2
San Cristobal de las Casas, Chiapas	218	39.5	5.6	43.2
Villahermosa, Tabasco	1,900	27.9	1.2	35.1

Based on the experiences accumulated in the drinking water loss study in Mexico, a methodology was developed at IMTA (*Ochoa, Bourguett, 1988*)[31], which was widely disseminated throughout Mexico. Using this methodology, the city of Querétaro realized water savings of 80 L/s with the introduction of a program to improve physical efficiency in 32 distribution zones, benefiting a total of 309,000 people and increasing physical efficiency from 69% to 85% in those zones in 2002. US$ 710,000 million was invested, resulting in an average of US$ 2.30 per person benefited. This cost includes only the investment made to conduct the program and does not take into account the cost of the installed infrastructure, or previous leak control programs, sectoring, metering, etc.

If efficiency is increased in Querétaro, Mexico to 85%, 1,280 GWh of energy and US$ 120 million could be saved just from the energy wasted in the water lost to leaks.

For Mexican drinking water systems, the cost of reducing leaks from an average of 35% to a technically desirable level of 15% implies a cost, on average, of US$ 7.23 per person.[32] With an expected population of 112 million inhabitants by the year 2010, US$ 810 million is required to reach this level.

[31] Ochoa-Alejo L y Bourguett V, *Comprehensive Loss Reductionin Potable Water*, (original text in Spanish: *Reducción Integral de pérdidas de agua potable*), IMTA edition, Jiutepec, Morelos, México, 1988.

[32] Ochoa A. L., *Action Plan to increase and control efficiency* (original text in Spanish: Planeación de acciones de incremento y control de eficiencia), edited by CNA and IMTA.

BRAZIL

Brazil's National Sanitation Information System (*Sistema Nacional de Informações sobre Saneamento*) (SNIS) is an annual survey of water and sanitation utility information. Information about energy consumption in water utilities, especially survey data collected as part of a national initiative is rare, so this data showing the relationship between water losses and energy losses provides valuable insight. Water losses in water distribution networks throughout the country totaled 5.6 billion m^3 in 2003. *In Brazil an average of 44% of water is lost to leaks and system inefficiencies.*

SNIS also reports energy intensity of Brazilian water systems, allowing the calculation of the energy waste due to leaks, shown in **Table X**. Water losses alone waste 3.5 billion kWh per year in Brazil, to say nothing of inefficient machinery or pumping systems, costing the water sector an additional US$ 230 million per year. Water lost in the distribution system is also not billed to customers, though the SNIS tracks an independent indicator that measures non-revenue water (larger than distribution losses), representing an additional monetary loss to the utility.

Table X. Loss Analysis for the Brazilian Water Sector (2003)

REGION	Distribu-tion Losses (1,000 m^3/year)*	Distribu-tion Losses (%)*	Energy Intensity (kWh per m^3)*	Energy Losses (1,000 kWh per year)	Effective Electricity Rate (US$/kWh) **	Losses with Energy Consumption (US$/year)**
North	414,760	65.5	0.56	232,265	0.07	15,484,367
Northeast	1,148,611	47.6	0.70	804,028	0.06	50,623,956
Southeast	2,970,403	41.7	0.65	1,930,762	0.06	114,415,536
South	772,269	43.1	0.43	332,076	0.10	34,437,488
Centro-western	302,784	39.1	0.69	208,921	0.07	14,701,836
Average		**44.0**	**0.62**		**0.06**	
Total	**5,608,827**			**3,508,052**		**229,663,183**

*As reported in SNIS 2003.

** Average, based on a conversion of US$1 = R$2.7

VII. Financing Energy Efficiency: Current Situation in Mexico and Brazil

A. Issues Faced by Water Utilities that Complicate Financing

Low Tariffs and Collection Rates

In spite of the financial autonomy enjoyed by water utilities in Mexico and Brazil, they face a long list of problems that impair their technical and financial effectiveness. On the financial side, tariff collection rates are low, and some of the largest customers in default include government entities at the state, municipal, and federal levels. Rate adjustments are politically difficult and often involve a very lengthy process for negotiating rate increases. Bill collection rates are low and accounts in default are still entitled to service.

In Mexico, for example, the Mexican National Water Commission (CNA) sampled 27 cities and found that rates fluctuated between US$ 0.09 per m^3 and US$ 0.81 per m^3 with an average water consumption range of 30 m^3 per month.[33] More likely, given the fact that most user databases are out of date, real revenue averages are closer to US$ 0.14 per m^3, a revenue recovery rate not considered adequate to cover operations and maintenance costs, let alone future investment and asset replacement requirements.

Technical Issues

On the technical side, water utilities are typically grappling with numerous issues:

- Lack of staff capacity, both managerial and technical, largely due to the short terms of senior mangers. Low morale can also be a problem.
- User information is often poorly organized, as is water consumption information.
- Administrative and operational deficiencies due to rapid rotation of staff.
- Operations and maintenance is focused on responding to emergencies and other short-term problems. Plans and programs have often been prepared without taking into account the availability of water in the region, promoting disorderly demand growth.
- Water loss, both technical and commercial, varies between 30 and 50% of supplied volume.
- High energy consumption and costs caused by inefficient pumping systems, poor system design, high rates of water loss, and deteriorating distribution systems.
- Poor metering of water supply and consumption. Only 35% of consumption and 50% of supply is metered, making it difficult to pinpoint system performance.
- Inadequate operation of wastewater systems and deteriorating collection networks, insufficient combined sewer drain systems that overflow in the rainy season, and poor flow information.
- Culture lacking in water conservation and efficiency.

[33] *Situation of the drinking water, wastewater and sanitation sub-sector as of December 2003*, (original text in Spanish: *Situación del subsector agua potable, alcantarillado y saneamiento a diciembre de 2003*), National Water Commission, 2004.

- Inadequate data collection and management systems.

PERFORMANCE CONTRACTING

Performance contracting is a contractual arrangement for evaluating and recommending energy efficiency measures and for implementing one or more of those measures, typically by a private-sector firm that specializes either in energy efficiency or in services that result in significant energy savings as a byproduct of the project. Often the arrangement is one of shared savings and risk reward where the private sector firm, usually an energy service company (ESCO), assumes the financing risk and is paid (rewarded) through a share of the energy savings, with the remaining share going to the client (e.g., the water utility).

A recent World Bank review of energy efficiency projects highlights the potential advantages and drawbacks to financing and implementing efficiency measures through ESCOs. ESCO business models can provide great value by attracting private sector technical expertise and financing, shielding end-users from technical risks, and providing significant business incentives to effectively develop projects. Potential problems with creating technically capable ESCOs and sound markets for ESCO services in developing countries include:

- the lack of legal and financial infrastructure to support ESCO business models;
- the lack of appropriate business skills among ESCO staff; and
- limited equity markets and a lack of investors willing to support ESCO development.[34]

In spite of these potential drawbacks, financing energy efficiency projects through performance contracting has a growing track record in the manufacturing, tourism, and hotel industries of Mexico and Brazil, where there is an increasingly mature understanding of the economics of energy efficiency. While new financing concepts need be adapted to the realities of a given region, numerous examples exist of successful efficiency projects financed through performance contracting, and there is a community of energy efficiency private sector enterprises, organizations and advocates with specialized efficiency knowledge. In the water sector, however, examples of performance contracting are extremely scarce. Section VIII.B summarizes one of the rare examples where performance contracting was used with a water utility.

Of the entire gamut of energy and water efficiency and conservation measures available to a utility, some of the more easily financed by performance contracts are:

- Optimization of electromechanical efficiency in pumping systems
- Optimization of power factor
- Peak load management through load shifting or back-up generation
- Installation of automation systems including automated variable speed drives
- Integrated programs for water loss reduction including leak detection, sectorization, and hydraulic modeling

[34] Singh, Jas. World Bank Environment Department. *World Bank GEF Energy Efficiency Portfolio Review and Practitioners' Handbook*. January 2004.

- Increase in bulk and individual flow metering coverage
- Conversion of wastewater treatment plants from traditional equipment to fine bubble aerators

The best combination of measures for a particular utility is determined from an investment-grade energy and water audit.

In Brazil, water and sanitation utilities might have ample opportunity for savings and a well-founded case for making efficiency improvements, but unless they can fund the changes themselves or apply federal money to the projects, many projects with short payback periods are not implemented. Complicating the situation is the widespread belief that Public Law 8666 discourages or even prohibits public agencies, such as state owned water utilities, from entering into performance contracts with private partners. However, while 8666 does provide specific guidelines that direct how and when public entities should solicit services and products, it does not specifically prohibit performance contracting arrangements. Generally, it is thought that where there is a valid case and a strong will to overcome these existing misconceptions concerning the law, and where performance contracting can be proven to be an effective tool for improving water services, performance contracting models that make use of outside sources of expertise and finance are valid models within the scope of Brazilian legislation. In Mexico, the financing climate for energy efficiency projects differs in that barriers to implementation of performance contracting lie more in the technical capacity to do so, and in the lack of institutional groundwork.

B. National Government Efforts to Fund Energy Efficiency

The Government of Brazil has created a number of energy efficiency funds and agencies in charge of promoting investments in water and sanitation. A piecemeal approach and bureaucratic inefficiencies, however, hamper these good intentions. The principal financing agents in the sanitation sector are the *Caixa Econômica Federal* (CEF) (Federal Economic Fund), which administers the funds from the *Fundo de Garantia de Tempo de Serviço* (FGTS) (Fund for Guarantee of Time of Service) and the *Fundo de Amparo ao Trabalhador* (FAT) (Worker Safety Fund). The *Banco Nacional de Desenvolvimento Econômico e Social* (BNDES) (National Bank for Economic and Social Development) also plays an important role in financing water and wastewater infrastructure in Brazil. **Annex 3** lists various Brazilian programs relating to water and energy efficiency project financing.

The Mexican Government has limited funding for water and energy efficiency project financing (see Annex 3 for the key programs). The Mexican Constitution specifies that town councils are responsible for providing drinking water, wastewater and sanitation systems in Mexico. Responding to this mandate, councils have formed their own water utilities. Today in Mexico there are approximately 1,200 utilities, of which 389 serve cities with populations over 20,000 inhabitants. Only three of these are privately operated concessions, Cancun, Aguascalientes and Saltillo. The Mexican response to this situation has been to focus on the promotion of efficient water use programs directed toward urban inhabitants, development and introduction of bulk-metering of diversions and important points of bulk water supply, individual home metering, water loss reduction efforts, tariff systems that promote water conservation, demand side efforts such as installation of water-saving devices in homes, user participation in conservation, and installation of leak proof joints in

wastewater networks. Many of these efforts have evolved from the national planning exercise embodied in the National Hydraulic Plan (PNH). PNH focuses on increased coverage and quality of the drinking water, wastewater and sanitation services.

VIII. Recommendations for Improving Water Access in Latin America through Energy Efficiency

It is an ambitious undertaking to transform the Latin American water sector into an efficient enterprise, one requiring the participation of multiple stakeholders representing diverse sectors and interests. Only with coordinated actions on policy, capacity building and resource allocation can Latin America's water sector move to dramatically improved levels of energy efficiency. Financial institutions, at the local, national and regional levels, must promote incorporation of efficiency into lending covenants. Governments must put in place step-wise processes to eliminate flat-fee tariffs, allowing energy and water prices to rise to market levels.

At the water utility level, relatively small amounts of financial assistance can provide technical assistance and funding for electromechanical system improvements and water distribution rehabilitation, which translate into reduced energy and water costs for utilities and improved water access for residents. Small grant programs have proven effective in Mexico's FIDE-funded effort, for example, a program that targets small grant funding in support of energy efficiency work. Similar programs targeting the water sector can spur progress. Water utilities that make the commitment to efficiency can also benefit greatly from an interactive repository for information relating to water sector energy use, facilitating the development of regional energy benchmarks for energy use and water consumption. In Brazil this role is filled by the SNIS initiative, part of the World Bank-funded Sanitation Sector Modernization Program (PMSS) of the Government of Brazil. These macro-level steps will give utilities the incentive and freedom to adopt new energy management models that fully accommodate the benefits made possible through efficiency.

The recommendations in this paper are organized into two broad types: the role of financial institutions, donor agencies and multilateral banks in financing efficiency projects, and the role that governments can play.

A. Financing Efficiency: the Role of Financial Institutions and Donors

Investments in energy efficiency tend to be incremental and modular with a rapid payback period, requiring a far shorter loan period than that necessary to build a new power plant or new infrastructure to extract bulk water. In spite of these financially and logistically compelling factors, there are a number of obstacles to implementing energy efficiency projects, one of the most difficult being to secure financing for relatively low-cost projects that financing institutions often do not understand.

Raising Awareness in Financial Institutions

Energy efficiency projects are not widely understood by financial institutions around the world, even though the basic criteria used to assess other lending opportunities—such as risk assessment, rates of return, and credit worthiness—also apply to energy and water efficiency projects. Evaluation factors will not appear as favorable if the financial institution views energy efficiency projects as high risk because they are unfamiliar with some of their characteristics. One characteristic that financial institutions tend to overlook is that the cash flow generated by energy efficiency projects is an asset, or collateral, that must be valued in order to obtain an accurate financial evaluation of the project. Water utility case studies

have demonstrated that savings are typically at least 20%, resulting in a significant cash flow. Savings estimated through an investment grade audit—one performed according to recognized standards—should be counted as additional equity. Another important feature for financial institutions to recognize is that the processes and electromechanical systems that dominate the water sector are a manageable credit risk, owing to the ease of metering and monitoring savings.

Another obstacle making financing institutions reluctant to finance efficiency projects is the low cost of efficiency projects. Financial institutions view the transaction as too time consuming, and therefore expensive, relative to the size of the loan. A small water infrastructure loan for water source diversion and conveyance, for example, dwarfs an IDB loan to Mexico's FIDE for energy efficiency projects. One way of reducing transaction costs is to bundle a set of energy efficiency projects, for example for a number of municipalities within a given state. Another way to reduce transaction costs is to create a streamlined guideline for financial institutions to use to quickly process energy efficiency projects. A donor agency, either a bilateral agency or multilateral development bank, can catalyze water sector efficiency by funding an organization that specializes in water sector energy efficiency to create such a guideline for financial institutions to use in Latin America.

In Brazil, the largest barrier to performance contracting in the water sector have proven to be the reticence of local banks to finance efficiency equipment, combined with a general distrust of the performance contract as a viable mechanism. Compounding the situation is the widespread misconception that Public Law 8666 prohibits performance contracts between energy service companies and public entities, a serious impediment since the vast majority of water utilities in Brazil are public. The solution to all of these barriers is education, another need that donor agencies—together with their government agency counterparts—are ideally positioned to fill.

Guarantee mechanisms that reduce financial risk for local financial institutions is another means of promoting a more widespread acceptance of energy and water efficiency financing. The U.S. Agency for International Development's Development Credit Authority has demonstrated the effectiveness of this tool for energy efficiency projects in Bulgaria and Ukraine, and the International Finance Corporation has undertaken similar guarantee programs in Hungary, Latvia, Lithuania, the Czech Republic, and Slovakia. Guarantee mechanisms are useful complements to technical assistance to catalyze efficiency in the water sector.

Raising Awareness in Water Utilities and Municipalities

On the other side of the transaction are the water utilities and municipalities, which in developing countries especially, rarely have the ability among their staff to prepare the documents and conduct the negotiations necessary to obtain financing for municipal projects. In some cases municipalities or utilities cannot obtain financing because they are not creditworthy, especially for very large, expensive infrastructure investments that come with added risk to investors. In many cases, however, the main barrier is a lack of knowledge. As part of a campaign to increase awareness of the opportunities available through efficiency, a helpful role for donor agencies or government energy efficiency agencies like FIDE in Mexico or PROCEL in Brazil is to fund audits in strategically chosen

water utilities. For a further-reaching impact, though, donor assistance should provide technical assistance to walk a set of pilot water utilities and/or municipalities through the entire energy efficiency process, from audits to obtaining financing through to monitoring and verifying results, including quantifying and documenting the resulting carbon emission reductions. The results should then be shared with financial institutions, municipalities and utilities, as well as appropriate government agencies.

Donors and financial institutions must also leverage the initiatives that already exist to catalyze awareness within institutions and utilities, such as those with FIDE in Mexico and PROCEL in Brazil (see Section XII). Local NGOs like ANEAS, the Mexican National Water Utility Association and ABAE, the Brazilian Water and Energy Association, ABES, the Brazilian Association of Sanitation Engineering, and others have increasing experience with promoting and implementing energy efficiency projects in the water sector. The exposure of groups like the Alliance, ANEAS, ABAE, and ABES to developing energy efficiency projects should be consulted when identifying targeted mechanisms to adequately focus lending.

As with all new undertakings, limitations are gradually overcome through increased exposure to new concepts. Working with both the providers and recipients of efficiency financing—building the requisite capacity on both sides—is one of the best ways to promote the adoption of energy efficiency in the water sector. Provided that the demonstrations are numerous enough to reach a critical mass, and that results are thoroughly disseminated to water utilities and financial institutions, this approach of building capacity through demonstrations will form the foundation for an effective program to promote water sector efficiency.

B. The Role of Government

At the heart of any government effort to promote water sector efficiency should be to shift from the ingrained tendency of national and provincial governments to invest solely in water infrastructure that further indebts water utilities and governments, to first examine what can be accomplished through efficiency improvements. Bilateral donor agencies and multilateral development banks can play a major role in helping governments understand the financial and developmental advantages of efficiency in the water sector, and the numerous policy actions available to governments to facilitate the transformation to efficient water supply. This section outlines the key options available to governments, generally at the national level. The options can be divided into two broad categories: government programs to educate and increase awareness of the benefits and methods of water sector efficiency, and government policies that promote market penetration of efficient water and energy consuming products and services.

GOVERNMENT PROGRAMS TO EDUCATE AND INCREASE AWARENESS

Most of the initiatives and programs described in Sections X.A.2 and X.A.3 to build awareness in water utilities, municipalities and financial institutions are best done under the auspices of relevant national government agencies in collaboration with bilateral or multilateral donors. Since water is one of the most fundamental substances to sustain life, programs to promote efficiency in the water sector can run up against entrenched cultural ideals among the public. In such cases government education and awareness programs can

underpin ambitious national-level efforts to change the way people regard their use of water. In South Africa, for example, the national government is helping Johannesburg Water fund a local program to reduce enormous levels of water and energy waste by fixing pipes and household plumbing, along with a new system where residents pay for the water they consume. Paramount to the tremendously successful program was a public awareness campaign with the byline "Every drop counts". Public awareness campaigns are essential to the successful transition from flat-fee tariffs to consumption-based tariffs (discussed in Section X.B.2 below), and can be a key factor in the success or failure of other government goals to promote water sector efficiency.

BENCHMARKING INDICES

Economic incentives that reward and motivate improved energy and water efficiency can be bolstered by indices designed for water utilities, established by federal agencies and maintained either by these agencies or reliable designated organizations. Some networks of water sector indicators do exist, but none of them adequately evaluate a decision making process for investments in efficiency versus new infrastructure.

At the international level, the Water and Sanitation International Benchmarking Network (IBNET), funded jointly by DFID and the World Bank, provides the opportunity for local benchmarking initiatives to undertake international comparisons by standardizing water and wastewater utility performance indicators. So far, the dataset only includes three countries in Latin America: Peru, Uruguay and Argentina. The network does not collect data on energy intensity or total energy costs, though "annual electrical energy costs as a percentage of total annual operational costs" is a defined indicator. Unfortunately, this data was not collected in any of the Latin American Countries for which data is available.

At the regional level for Latin America, the Asociación de Entes Reguladores de las Americas (ADERASA) (Association of Water and Sanitation Regulatory Entities of the Americas, www.aderasa.org), has a benchmarking working group. Mexico hosted an ADERASA benchmarking workshop in February 2005 and has become an active ADERASA member, but performance indicators resulting from this effort are unavailable.

At the national level, however, reliable benchmarking systems to evaluate water utility efficiency are mostly lacking throughout Latin America. In Mexico the federal authority charged with regulating the water sector is the *Comisión Nacional del Agua* (CNA) (National Water Commission), which developed a system of indicators in the *Programa de Modernización del Sector Agua* (PROMAGUA) (Water Sector Moderization Program), which provides economic incentives as a function of the level of efficiency. However the data does not capture energy. (More information about this program can be found in Annex 3.) Brazil has the most complete system, in the Ministry of Cities' *Programa de Modernização do Setor Saneamento* (PMSS, the Sanitation Sector Modernization Program), which collects data on the water sector and compiles it into an annual database, the *Sistema Nacional de Informações Sobre Saneamento* (SNIS, the National Sanitation Information System). SNIS is complete enough that can be used as the basis for a national benchmarking effort, and in addition a major thrust of the program is to provide financing advice by ensuring financial viability and efficiency through operational or managerial restructuring. However, the program

could have an even greater impact by incorporating the effect of energy savings on a water utility's financial viability.

GOVERNMENT POLICIES THAT PROMOTE MARKET PENETRATION

Tariffs

Although energy efficiency in water utilities is implemented at the local level, it is not always a local issue. National policy determines many of the incentives for and impediments against wiser, more cost-effective energy and water management. For example in many Eastern European countries, energy and water tariffs that are not based on actual consumption, coupled with extensive price-distorting subsidies remove any incentive to use resources efficiently. Many of these policies are decided in national capitals by politicians far removed from the daily task of running municipal utilities.[35] Moreover, local governments often support continued price-distorting subsidies and flat-fee tariffs for political reasons, or they do not have budget authority to change policies enacted at the national or provincial level. In many developing and transitional economies, cities depend on the national government for budget outlays, have little control over their budgets, and therefore few if any incentives to reduce operating costs or generate revenue. Governments must put in place step-wise processes to systematically reduce price-distorting subsidies, allowing consumers to be charged for energy and water use based on consumption. An intensive public awareness campaign will be required to convince the public that water prices linked to rates of consumption are necessary to ensure for the supply of ample, clean water now and for future generations.

Legislative Incentives

Legislative incentives for investments in efficiency are a cornerstone to sustainable water and energy use. Among the most important legislative priorities are those that create the economic incentives and legal frameworks that allow performance-based financing arrangements to flourish. In Brazil, for example, the government could provide a tremendous boost to performance contracting by addressing Public Law 8666—either an educational campaign to remove the current widespread misconception that this law prohibits performance contracts with public entities, or by changing the law to be less ambiguous.

Governments can also do a great deal to promote efficiency by providing incentives or financing priority to water utilities that include energy efficiency as an objective of their larger infrastructure reform or expansion projects. FIDE's program in Mexico is noteworthy for the relatively easy access to energy efficiency funding that it offers, leading to concrete energy savings and reduced carbon emissions. A similar program targeting efficiency opportunities in the water sector would have dual benefits resulting in energy reductions and improved water access.

It is important to pay attention to the details of incentives, to ensure that they are applied as intended. The CAGECE case study in Fortaleza, Brazil illustrated this when the financing

[35] See www.munee.org for more information about the Alliance to Save Energy's Municipal Network for Energy Efficiency program in Eastern Europe's economies in transition.

intended for further efficiency measures was lost because the funds had to pass through the state energy utility before going to CAGECE. This experience illustrates that, to the extent possible, financial resources for energy efficiency projects and their associated risk should be made available directly to the water utilities themselves, without intermediary hurdles.

Standards and Labeling

National government can drive the market penetration for efficiency by adopting energy and water efficiency standards for electric and electronic products and electricity installations in civil construction and industrial units. All measures to promote the energy efficiency market will stimulate municipal level demand side management programs for both water and energy.

According to the Collaborative Labeling and Appliance Standards Program (CLASP), Brazil first adopted labeling in 1984 and has since established a variety of voluntary and mandatory labels for several products. With assistance from PROCEL, the federal government has taken steps toward establishing a formal regulatory framework for energy efficiency standards and labeling. A mandatory label for energy efficiency in clothes washers is the only label that addresses both water and energy efficiency.

Mexico first adopted energy standards in 1995 and has since established standards for eighteen products. Many of their standards are modeled on those of the United States, but have been adapted to local situations and experience from their own program. In addition to minimum energy efficiency standards, comparison labels also exist for four products and endorsement labels are used on two of these products plus seven others. Labels or standards for consumer products and appliances that use water and energy such as low-flow and self-heating showerheads, clothes washers, dishwashers, toilets, and faucet aerators can lead to increased uptake of energy efficiency technologies. Development of standards for water and wastewater system design and equipment procurement would provide needed guidance to utility managers on minimum standards of practice.

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X. ANNEX 1: Case Studies in Brazil and Mexico

This Section presents three case studies of municipal water sector efficiency from Brazil and Mexico. Two of the projects, in Fortaleza, Brazil and Veracruz, Mexico, received funding from the U.S. Agency for International Development. Regarding units, the inverse of energy efficiency is defined as the energy intensity of a process, or a quantity of energy per unit of product. Here the units of kWh/m^3 are used to describe the energy intensity of a process or system in the water and wastewater sector.

A. CASE STUDY: Fortaleza, Ceará, Brazil

THE CHALLENGE

The importance of this project was emphasized by the energy crisis Brazil underwent in 2000 and 2001. Because over 70% of the energy generated in Brazil comes from hydropower, droughts and energy shortages are inextricably linked. During the energy crisis and drought of 2000 and 2001, all consumers were required to reduce energy consumption by 20%.

Figure 7. Booster Station at CAGECE

The Alliance to Save Energy has worked alongside CAGECE in the Northeast of Brazil since 2001 in order to develop and implement measures for more efficient use of water and energy. This partnership aimed to improve the distribution of water and the access to sanitation services, while reducing operational costs and environmental impacts. The partnership was important not only for reducing energy use at CAGECE, but also for the example that was established for similar projects nationwide, since the water and sanitation sector represents some 2.3% of Brazil's energy consumption.

Water distribution systems are designed considering population projections that are based on statistical and historical data that is projected over a 20 or 30 year planning horizon. Because of this, many systems are over-designed in the sizing of storage, treatment and distribution installations. Since these installations consume energy, especially the booster stations, the over-design carries with it energy consumption levels that are much greater than necessary to provide for adequate demand. These design criteria affect not only the pumping stations, but also the sizing of pipes, the capacity of reservoirs and the construction of treatment facilities and booster stations. Water systems do need to be able to expand to satisfy increasing demand, but not while sacrificing efficient use of energy.

OBJECTIVE

The focus of the partnership between the Alliance and CAGECE was to develop a methodology, providing CAGECE with the tools and the know-how to produce initiatives that result in savings and rational use of energy and distributed water. As the work progressed, it became clear that the model being created would be useful to other water and sanitation companies in Brazil looking for ways to increase efficiency.

APPROACH

An automation system in water distribution systems is allowing operators to obtain strategic data to control equipment in real time. The automation of the water supply system in the Fortaleza Metropolitan Region, managed by the Companhia de Água e Esgoto do Ceara (CAGECE) and supported by USAID and the Alliance to Save Energy, allows for correction of deficiencies in the system, particularly those that are caused by over-design.

Along with the continuous efforts by CAGECE, the Alliance's actions in 2002 included:

- Establishing a baseline of energy consumed and water distributed for CAGECE
- Implementing efficiency measures that led to a reduction in operational energy consumption
- Developing a financing proposal with PROCEL in order to implement energy efficiency projects with CAGECE's operations crew. The technical support provided by the Alliance resulted in the development of energy efficiency projects, cost/benefit analysis, and specifications of equipment that could be financed.
- Arranging for R$ 5 million in financing for energy efficiency projects to CAGECE. These projects included rewinding and replacement of motors, maximizing existing pump systems efficiency, and increasing storage capacity to allow the shutdown of pumps during peak hours.
- Creating an operations procedures manual for CAGECE, compiling all information from the work developed. This manual serves as a reference for daily performance to operations crews and CAGECE management.

SPOTLIGHT: AUTOMATION AT CAGECE

As part of the energy efficiency program undertaken, CAGECE established an Operational Control Center for the water supply system of Metropolitan Fortaleza. The objectives of the automation of the water supply system of Fortaleza, were:

- Optimize operations to reduce energy costs;
- Improve system management by centralizing control;
- Speed up recognition of and response times to maintenance needs using sensors and by acting through controlling devices;
- Generate system diagnostics using historical records of operational data.

The main results achieved due to the automation of the water supply system of Fortaleza were:

- Reduced waste of treated water;
- Improved supply;
- Standardization of operational procedures;
- Reliability of operational data;
- Ability to act in real time with the system control devices;
- Reduced electric energy use:
  - ✓ Energy saved = 5.4GWh/year;
  - ✓ Avoided demand = 0.6 MW;
  - ✓ Percent reduction = 7.9%.

The baseline established in **Table XI** shows that before CAGECE instituted their access to 442,399 households. Nearly two years later, 55,597 additional households had potable water access with a negligible decrease in the amount of water supplied.

Table XI. Measurements Taken in the Fortaleza Metropolitan Area

Measurement	Dec 1998	Sep 2000	Difference
Actual Connections	442,399	477,996	55,597
Volume Distributed (m^3)	13,297,782	12,834,329	-3.5%

RESULTS

The Alliance and CAGECE have achieved success in reducing and rationalizing the use of electricity and the distribution of water. **Table XII** shows that over four years, CAGECE saved 87.8 GWh of energy, improving efficiency each year. Even through the number of consumers grew, there was a decrease in total energy consumption and cost. Growth rate in new connections far surpassed that for the volume of water distributed. By 2002, the utility maintained energy and water consumption levels while providing 88,000 new connections over the original baseline. Four years of official data show savings of over US$2.5 million.

Table XII. Energy Saved by CAGECE While Number of Connections Increased

	Number of Connections	Volume Distributed (10^6 m^3)	Avoided Demand (MW)	Energy Saved (GWh)	Annual Savings (US$)
Dec 1998	456,847	13.8	0.91	15.3	340,500
Dec 1999	478,771	13.6	1.33	18.4	461,000
Dec 2000	508,995	14.4	2.94	26.9	791,800
Dec 2001	544,861	14.5	3.38	27.2	938,000
Total				**87.8**	**2,531,300**

LESSONS LEARNED

CAGECE invested only about US$ 1.1 million (R$ 3 million) in energy efficiency measures to achieve the results shown in Table XII, realizing US$2.5 million in savings. As a result, CAGECE was initially approved for financing by the Energy Efficiency Fund of PROCEL to work with the World Bank to implement further efficiency measures. The Alliance helped develop five projects, including replacing motors with high performance motors, maximizing pumping efficiency, suspending pumping during peak hours, and increasing capacity of the current pumping stations and specifications relating to energy efficiency.

If implemented these projects would add a savings of 7 million KWh per year, with a total investment of US$ 2 million (R$ 5.4 million) by PROCEL and the World Bank. The cost/benefit analysis predicts a return on investment of 3.5 years. However, the financing opportunity was lost because funds were obligated to pass through the state energy utility in Ceará (COELCE) and the legal departments of COELCE and CAGECE could not come to an agreement.

B. CASE STUDY: Veracruz City, Veracruz, Mexico

THE CHALLENGE

Energy costs, which rank second in total operating costs, have motivated the water utility in Veracruz, Mexico to undertake significant steps to become more energy efficient. The Alliance to Save Energy assisted in developing a plan to save energy based on its energy and water saving concept (Watergy). The plan helps to improve management in energy and water use efficiency.

In 2003, the Metropolitan System of Water and Sanitation at Veracruz (SAS) began a process of concerted transformation. This process included a focus on service improvement, operational and managerial streamlining, as well as a significant emphasis on implementing energy efficiency. The energy efficiency focus was undertaken in partnership with the Alliance to Save Energy and supported by the United States Agency for International Development (USAID).

This system, which serves 628,000 users, provides water and sanitation in the municipalities of Veracruz, Boca del Rió and Medellín in the state of Veracruz. Its principal sources of water include the large Jamada River which supplies 62% of the total water produced; the rest is produced in 43 deep wells. Its production averages 7.5 million m^3 monthly, with seasonal variations.

The utility consumes 3,659,720 kWh of electricity monthly, as follows (see **Figure 8)**:

- 81% (2,966,811 kWh/month) for the production of potable water (sources of supply);
- 17% (633,749 kWh/month) in the treatment of sewage; and
- 2% (59,160 kWh/month) for offices

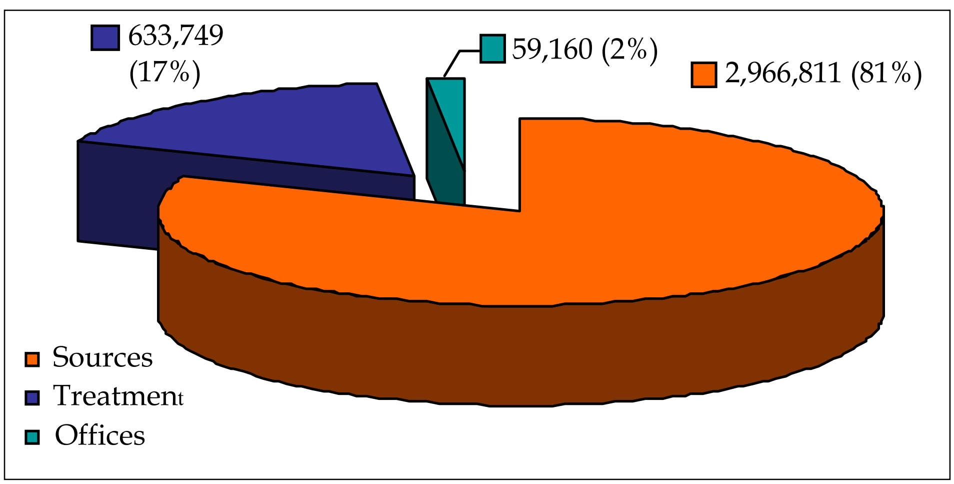

Figure 8. Distribution of Energy Consumed by Water Utility in Veracruz

Water purification consumes 49% of total energy used during the process of production and supply of potable water. Underground sources (wells and pumping) use 51% of the energy in this category.

Before the project, parts of the system also experienced severe interruption of service of up to 5 hours at a time. The goal was to increase the energy efficiency of the operating system, improve the conditions of system operation, and to provide better service to the customer.

APPROACH

The project was based on the energy consumption analysis shown in the energy profile of Figure 8. Based on this, the importance of energy consumption from production sources is clear. However, the energy use profile could change considerably if the utility improves their wastewater collection and treatment coverage.

The energy distribution for production sources is given in **Figure 9**. The surface water treatment, while consuming half of all energy needed for water diversion, generates only one energy bill. The remaining energy consumed by potable water sources, including nearly 50 wells, generates approximately 50 separate energy bills.

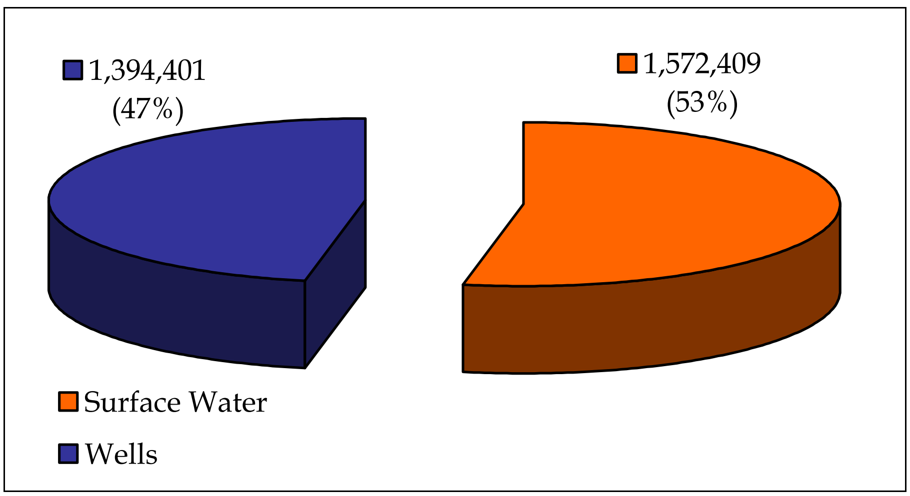

Figure 9. Energy Needed to Extract Drinking Water from Surface Water versus Ground Water in Veracruz

Calculating the energy intensity of the different water sources, the optimum level of efficiency in the production of water serves as a base for establishing energy savings goals for the program. **Figure 10** shows that the energy intensity of extracting groundwater sources is 57% more than that of surface water sources.

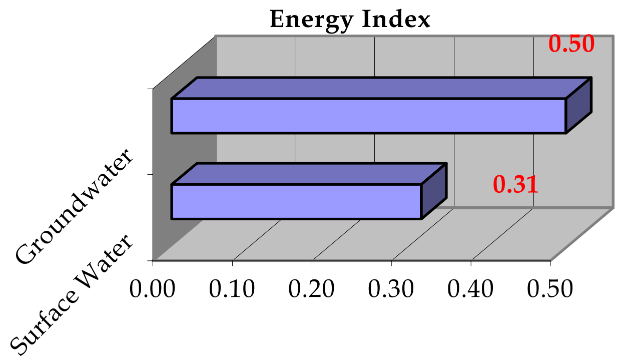

Figure 10. Energy Indices for Groundwater and Surface Water in Veracruz

Based on this data, the following actions were taken:

- An energy diagnostic using production statistics and electricity bills
- A feasibility analysis of energy saving measures such as demand management and load shifting to off-peak hours, and power factor optimization
- Collection of data and field measurements using specialized equipment for analyzing electrical networks and the electromechanical efficiency of pumping systems
- Data analysis and the selection of high efficiency pumping equipment
- Analysis of the physical conditions of deep wells to evaluate their condition and determine rehabilitation and maintenance options
- Utilization of hydraulic modeling as a tool for defining pressure and flow sectors in the system.
- Sectorization[36]

A specific example of the application of the Watergy model is the sector of the Veracruz system called Volcanes. Undertaken as a "pilot" sector, the Alliance worked with SAS to implement energy efficiency measures, with the intent of extrapolating successful measures to all sectors of the city.

SPOTLIGHT: VOLCANES SECTOR

The Volcanes Sector lies on the south side of the city of Veracruz and has a population of 25,000 inhabitants. Before the sectorization project, which is a part of the strategy to improve pressure control and the volume of water supplied to the zone, this sector was connected to the rest of the distribution network. The water was supplied by three different sources, the Volcanes well, well 43, and well 50, to bordering zones without any controls

[36] Sectorization, sometimes called zoning, is the process of isolating a section of a distribution system using valves. It is a key first step in developing hydraulic models of the system, GIS mapping, and conducting maintenance programs such as unidirectional flushing, ultrasonic leak detection, and valve exercising.

during times of fluctuating demand. This caused the use of the water supply to be inefficient with three principal effects:

- Excessive operational energy use for the pumping system and interrupted service when the pumps were operating at their maximum capacity
- Losses of water to the supply zones bordering the Volcanes sector and excessive operating pressure in the sector itself, which caused increased numbers of leaks.
- Low level of service to the local population, reflected in consistent complaints (an average of 100 complaints per month about poor service)

Note: This sector does not include a storage tank, the water is supplied directly to the distribution network.

RESULTS

In summary, this project has achieved savings to date that come from basic strategies on the supply side, using a variety of methods including:

- Optimization of electromechanical efficiency resulting in savings of 153,254 kWh/month, with a payback period of 1.7 years;
- Leak Detection and Water Conservation resulting in savings of 35,500 kWh/month.

The baseline energy intensity of the SAS system, taken at the beginning of the Watergy program was 0.48 kWh/m^3. Over the development of the program, the energy intensity had been reduced to 0.39 kWh/m^3 resulting in US$394,000 in savings for the utility. The benefits to SAS and to the population it serves continue to increase as the Watergy methodology is replicated in other sectors in the system. Taking into account the energy consumption of respective sources, the future goals of the program include physical efficiency analysis and the adoption of methods to increase efficiency.

LESSONS LEARNED

To improve operational conditions, several corrective actions are highlighted as follows:

Sectorization

The optimal pressure and flow range of the sector was determined using hydraulic modeling tools. Once determined, isolation valves were installed so that the sector could be cut off from the rest of the system and supplied solely from the pumping system at the Volcanes well.

Well rehabilitation and improvements in electromechanical efficiency

The Volcanes well was rehabilitated and a high efficiency submersible pump was installed.

Automation of the system and installation of a variable speed drive

To avoid excessive energy consumption and to eliminate the necessity of constructing a storage tank, an automatic control mechanism was installed that includes a variable frequency drive. Controlled at a constant pressure, the drive reduces the pump's energy consumption by 30% compared to when the pump operates without the drive.

The variable speed drive allows the Volcanes pump system to save energy during hours of low demand. The reduction of pressure in low demand hours also reduces leakage substantially. **Figure 11** demonstrates the operation of the variable speed drive:

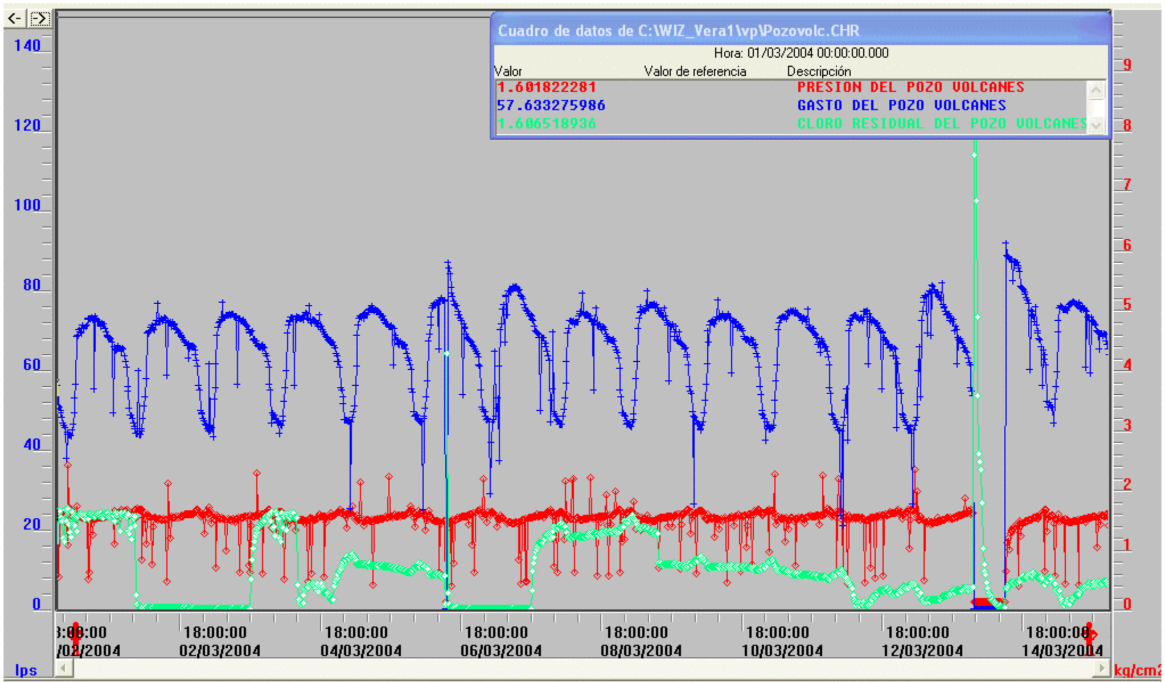

Figure 11. Operation of Variable Speed Drive

This monitoring forms a part of the Supervisory Control and Data Acquisition (SCADA) system that SAS has implemented as part of its improvement strategy and will be applied in a similar way to other sectors of the city. The continuous monitoring of the sector, together with an aggressive program of maintenance and leak repair, has permitted SAS to reduce water losses to a minimum.

The course of action described above has shown quantifiable results, including the following highlights:

- Elimination of public complaints. The number of monthly complaints in this sector has decreased to almost zero. This improvement has allowed SAS to leverage user confidence to raise their income from previously unpaid monthly service bills.
- Energy Savings. The use of the variable speed drive in the Volcanes pump system has an electromechanical efficiency of 72% compared to 45% previously, and the combination of measures has allowed for 45% energy savings compared with previous consumption.

Due to pressure control, water losses have been substantially reduced. Combined with a leak and loss recovery program, energy consumption will be reduced further.

C. CASE STUDY: Querétaro City, Querétaro, Mexico

THE CHALLENGE

The State Water Commission's (CEA), supplier of potable water for the city of Querétaro, decided to implement a program promoting improved efficiency in water distribution zones based on disparities which emerged while examining historical expenditures and profits related to control of water losses. In 1995, over half of the water supplied and distributed within the potable water supply system was lost: leaks at household intakes accounted for 26%, billing errors for customers without meters accounted for 17.1%, leaks in pipelines were 8.2%, and metering errors 0.6% (see **Table XIII**). This led to the conclusion that costs in maintenance and water waste produced were elevated.

Table XIII. Water Balance in Querétaro (1995)

Supply/Demand/Loss	Quantity (m^3)	Percentage (%)
Total Water Supplied	**+ 49,109,641**	**100.00**
Billed Water Consumption	**- 23,656,114**	**48.17**
LOSSES	**+25,453,527**	**51.83**
Metering errors	275,014	0.56
Leaks at household intakes	12,768,507	26.00
Leaks in pipelines	4,022,080	8.19
Billing errors in customers without meters (fixed rate)	8,387,927	17.08

The CEA, to create the "Zoned Distribution System" program, initially sketched out the integrated plan of the zoning system identifying operational and physical limitations within the outlay of the city. They followed this with a pilot study on selected zones to define and validate the methodology to be used in the new program. Results from their studies indicated higher levels of efficiency within the system, ranging from 85-90%, benefiting 56,330 users (6% of the total population). The CEA Querétaro, based on the success of the pilot studies, initiated the Improvement of Efficiency in Zones Program (PMEC) with the support of the external companies and the Consultancy of the Mexican Institute of Water Technology (IMTA).

OBJECTIVE

CEA has introduced the "Zoned Distribution System" program **(Figure 12)** in order to improve its piping network. This new scheme aimed to reduce water loss through increased system and commercial efficiency, improving system operation and preventing the need for future extensions. The goal of the "Zoned Distribution System" program is to create and streamline each of the 144 water distribution zones, only 62 of which operate on a regular basis.

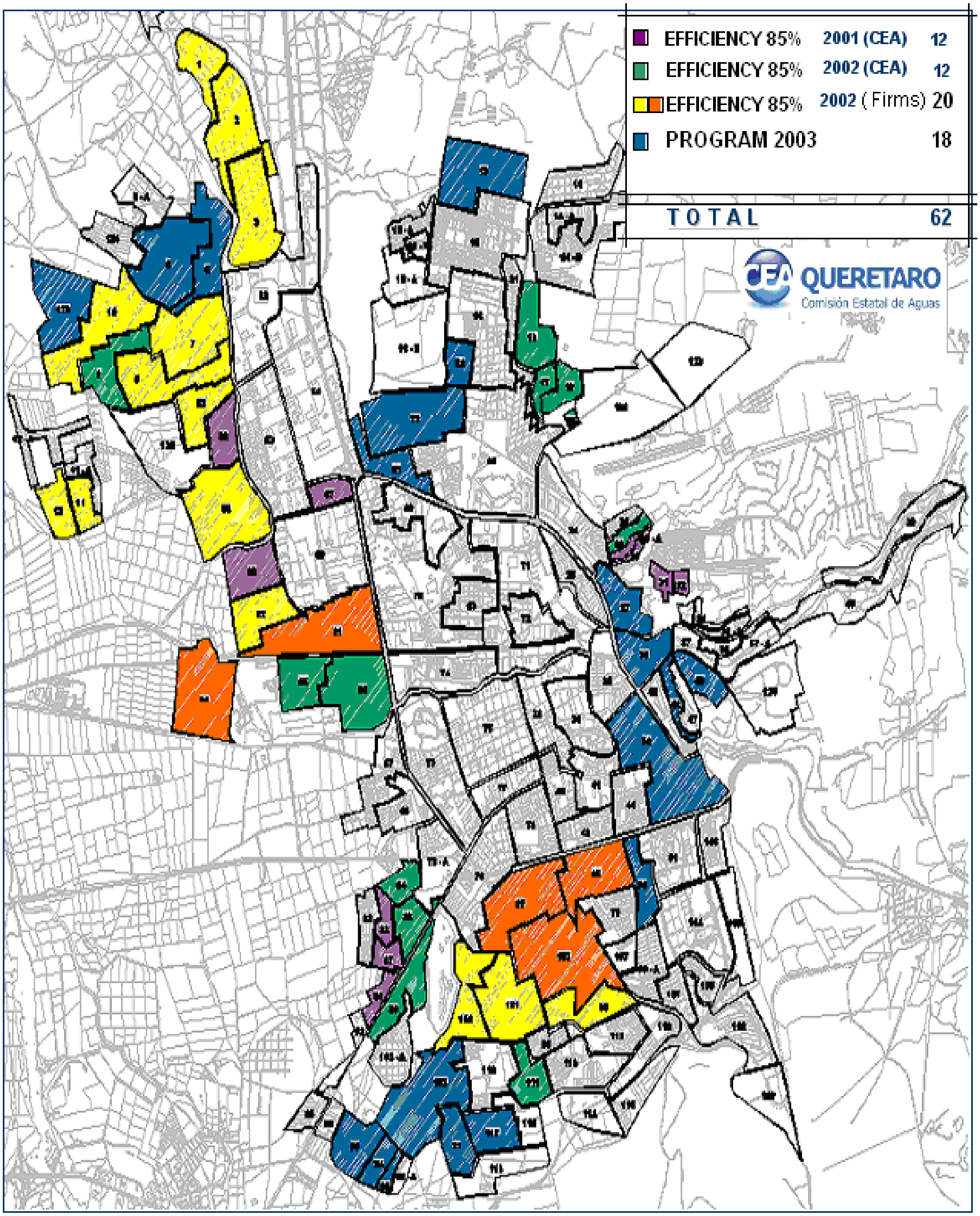

Figure 12. Water Distribution Zones for the City of Querétaro

APPROACH

The methodology used by the State Water Commission (CEA) in Querétaro, is similar to the approach used by the Mexican Institute of Water Technology (IMTA) that was developed based on the water supply experiences of the utility of Monterrey, Mexico and the water supply system of Querétaro. The approach used by CEA includes techniques used by hydrometric districts that complement the operating and administrative conditions prevailing in the Querétaro water supply system.

The methodology used involves a series of activities that could be classified into three groups:

Group 1

- Updating the zone information consisting of data management
- Development of a water balance
- Revision of property boundaries and customer database entries

Group 2

- Improvement of efficiency, beginning with the installation of a metering system to quantify water supply
- Elimination of leaks in intake structures, valve boxes and underground pipes
- Identification of irregular intake structures
- Review of user subsidies such as poorly assigned fixed fees for water consumption
- Test of the pumping system efficiency

Group 3

- Evaluation of the achieved results, where the levels of water recovery are determined, the losses are identified and accounted for, and the costs and benefits are calculated

The baselines used to verify and improve efficiency within the zones suffered from scarcity of background information, absence of measurements and network registries, and an outdated registry list of users. Where there was insufficient statistical information, CEA and IMTA established some of their own techniques which differed from traditional methods of evaluating efficiency. For example, rather than calculating the minimum nightly consumption index, users' by-pass valves were closed for a day in order to register the minimum flow reached in the supply point. Then, this was divided between the previous average registered flow over a period of three to seven days.

This project was carried out over two years, covering 49 zones, with the participation of three external companies and the supervision and consulting help from the IMTA. CEA made an investment of US$ 0.714 million during the first year (32 zones), and US$ 0.346 million during the second (17 zones), totaling US$ 1.06 million.

RESULTS

The work carried out over a short time frame to improve the efficiency of 49 zones, benefiting an estimated population of 442,700 users (88,363 branches), was exhaustive and intensive. The project achieved levels of efficiency from 69% to 86% in 2002, and 75% in 2003. Repairs were made on 7,595 leaks with a recuperated registry of 102 L/s and 5,811 unregistered users were identified. Total savings obtained through the regulation of unregistered users were US$ 2.9 million: US$ 1.9 million for contracting, plus US$ 1.0 million for annual invoicing. The cost-benefit ratio over the two years of the project was 2.7.

It is estimated that with the regulation of previously unregistered users, CEA conserved 2.1 million m^3 of water annually, plus 3.2 million m^3 per year for the recuperation of 102 L/s in leaks, adding up to a total of 5.3 million m^3 per year. Overall benefit from recovery of water was US$ 3.7 million dollars per year (for Querétaro, a cost of 0.69US$/$m^3$). The cost-benefit ratio for the water recovered was 3.47.

As a result of this program, electricity saved was 3.2 GWh/year, for an annual savings of US$ 0.3 million. Overall, the program has achieved efficiency goals in 49 zones, and realized the associated savings.

LESSONS LEARNED

An increase in efficiency within the Querétaro zoning system yielded economic and social benefits from improved water service. It is clear that the program should continue into the next two-year period to cover all of Querétaro zones, offering numerous benefits at a relatively low cost. In particular, it presents considerable savings in the consumption of electricity and generates a source of funding for new infrastructure, thereby improving performance within the Querétaro pumping system.

XI. ANNEX 2: Additional Watergy Efficiency Implementation around the World

Other examples of water utilities implementing energy efficiency measures as an alternative to new infrastructure are provided in this section. An overview of the approach to energy efficiency and the costs and benefits of implementation of energy efficiency measures versus installation of new infrastructure will be presented for each case, where available. At the end of this section is a discussion of lessons learned by the Alliance to Save Energy on the most effective approaches to Watergy projects.

A. South Africa: Pressure Management in Mogale City

Working with Mogale City authorities in South Africa, the Alliance identified the need to service, reset, and repair existing pressure reducing valves as an initial activity to create water and energy efficiencies in the city. While there were many opportunities for savings, pressure management was the least cost option projected to yield the highest result.

Based on recommendations made by the Alliance, two separate contractors were employed by Mogale City to service more than 130 pressure reduction valves during the months of December 2003 and January of 2004. Mogale City immediately experienced a sharp reduction in water purchases from the bulk water supplier. Following the application of this pressure management in Mogale City, 263,000 kL per month were saved with an approximate monetary value of $114,000. This was a 12% reduction in water purchased for the city. The energy needed to distribute one kL of water in Mogale City has been calculated to be 1.8 kWh, including the energy embodied in the bulk water supply. Using this estimation, the city's reduction in water consumption ended up saving the city approximately 473,000 kWh per month. As pressure management was the only efficiency initiative implemented at an operational level in Mogale City, these reductions can be directly attributed to the inspection, servicing and correct setting of pressure reducing valves.

B. South Africa: Performance Contracting in Water Supply in Emfuleni

The Alliance to Save Energy, funded by USAID, facilitated the implementation of a performance contract for the management of water network pressures in the municipal area of Emfuleni in South Africa. The project is the first in South Africa where performance contracting has been applied to a water supply project.

The pressure management project requires the contractor to finance, design, install, operate and maintain the facility for a period of five years with renumeration based on resulting savings in supply of water to the adjacent townships of Sebokeng and Evaton. Another unusual aspect of the project is that the contract, worth about 11 million Rand (US$ 1.7 million), is a BOOT (Build-Own-Operate-Transfer) type, which is normally applied to large, capital-intensive, concession-type infrastructure projects rather than to operations seeking efficiency. The capital cost of 5 million Rand (US$ 800,000) is being financed in full by the water resource planning firm (acting as an ESCO), through a loan to the firm from a commercial bank. After five years the infrastructure will be handed over to the municipality at no cost and is designed to operate for at least another 15 years.

The infrastructure, which became operational in September 2005, is dramatically reducing the high night flows previously experienced in Sebokeng and Evaton. These high night flows are symptomatic of large losses through leaks, both on private properties and within the water network, and represent a significant financial loss to the city because of poor payment levels. Just prior to the project, the night flows were recorded at around 2,800 kL per hour, enough water to fill two Olympic sized swimming pools every hour! This is the highest recorded night flow on record for almost a dozen countries. The project reduces supply pressures during off peak periods, especially at night, substantially reducing the levels of leakage without affecting the quality of service provided to the consumer. Annual savings to the municipality are expected to be 9 million kL of water, $4.5 million, and 14.25 GWh of energy, corresponding to over 12,000 tonnes of CO_2 emissions avoided per year.

The Alliance to Save Energy has played various roles in bringing this project to fruition, including conceptualization, assisting contracting arrangements and project management, and—once the pressure reducing valves are installed—acting as an Independent Technical Auditor to verify the savings achieved.

C. Balkans: Leak and Loss Reduction

Since 2002, the Alliance has been working with numerous water utilities and municipalities along the Balkan Peninsula—particularly in Montenegro and Bosnia & Herzegovina—to build awareness and capacity about ways to save water and energy. Governmental officials and businesses in these two countries see value in the Watergy concept because they understand that improvements in energy and water efficiency can have a direct impact on the increasingly important tourist industry along the coast. In 2002, water utilities in the coastal area (including the towns of Herceg Novi, Tivat, Kotor, Cetinje, Budva, Bar, and Ulcinj; **Figure 13**) produced and distributed 39 million liters of water, of which only 13 million reached end users.

Figure 13. Balkan Coastal Towns where End Users Were Receiving Only One-Third of the Water Produced and Distributed by Water Utilities

Due to the mountainous landscape, a majority of this water has to be pumped, requiring tremendous amounts of electric power. Tariffs are not at cost-recovery levels and 60% of water produced is not even billed. Lack of adequate maintenance during the last ten years

has further deteriorated the situation in coastal areas, jeopardizing the region's growth potential.

The Alliance developed an extensive and easy-to-use program of energy and water efficiency measures for such utilities, focused on reducing network leakages, improving the hydraulic efficiency of pipe networks, improving the efficiency of pumping and treatment facilities, and improving maintenance standards in order to extend the service life of existing assets. The project was piloted in a zone of the coastal town of Cetinje during 2004, with impressive first results:

- Water losses in the pilot zone reduced from 77 % to 21%
- This is the first time in the last 10 years, the town of Cetinje has round-the-clock (24-hour) water supply
- Monthly cost savings in energy for the pilot zone are at least €15,000 (US$ 12,000).

The results were shared with the water utilities of the other six towns shown in Figure 13 as part of the training the Alliance provided on water efficiency.

Thanks to the pilot's initial results, a more comprehensive water loss program was undertaken for the whole town of Cetinje. The Alliance proposed further efficiency measures for the project such as water leak detection, introduction of GIS and digital monitoring of the water supply network, as well as repairs of end-use water appliances. In addition to Cetinje, the Alliance successfully convinced city officials and utility managers from Budva, Bar and Kotor in Montenegro and ten water utilities in Bosnia and Herzegovina to invest their own resources in efficiency and water loss management staff and equipment. However more funding is needed in order to implement a comprehensive water and energy loss management program for the water utilities in these towns.

D. India: Bulk Supply System Auditing

In the south Indian state of Karnataka, the Alliance Watergy Program has assisted the Karnataka Urban Water Supply and Drainage Board (KUWSDB) to carry out energy audits in bulk water supply systems in four municipalities. These audits have shown that there are large energy saving opportunities associated with simple, low cost, energy savings measures often with a simple pay back period of less than one year. In the case of these four municipalities, an initial investment of US$ 385,000 is likely to lead to an annual financial saving of US$ 797,000, through an energy saving of 8.2 million kWh per annum. Most of these low cost measures have a simple pay back period of about six months and can be implemented through funds allocated annually for operations and maintenance. **Table XIV** shows the range of these measures in the Indian municipalities that were audited as well as the payback that was expected.

E. India: Capacity Building toward Ownership of Energy Efficiency

An important step toward ensuring the sustainability of energy efficiency efforts is building the in-house capacity of state level institutions to become centers of information, innovation and accountability in effective energy management. This also enables these institutions to take legitimate ownership of regional energy efficiency programs and to promote adequate,

Table XIV: Short and Medium Term Measures in Karnataka Municipal Water Supply Systems

Short Term Measures	Cost ($)	Simple Payback Period (years)
Surrendering excess demand	None	Immediate
Increasing the frequency of cleaning the suction sumps	None	Immediate
Improving water flow distribution	1,150 – 4,600	0.25 – 0.5
Power factor improvement	1,150 – 4,600	0.2 – 0.9
Improving pump operating efficiency	3,400	0.2 – 0.3
Rescheduling of pump operations	6,900	Immediate
Optimizing sizing of pumps	16,000 – 36,600	0.5 – 1
Installing lower head pumps	23,000	0.9
Replacing impellers	27,500	0.4
Medium Term Measures		
Suitable sizing of new pump	6,900	1.4
Reactive compensation in the system	9,200	1.5
Improvement in suction and discharge header	55,000	1.3
Replacing old pumps with energy efficient pumps	55,000 – 110,000	0.8 – 1.4

decentralized fiscal responsibility with regard to energy. As part of this capacity building process, the Alliance established an Energy Management Cell (EMC) at the Karnataka Urban Infrastructure Development Finance Corporation (KUIDFC) and trained its personnel in energy efficient concepts and practices.

The EMC at KUIDFC has sustained the Alliance's seminal efforts in capacity development by conducting outreach seminars for engineers and managers from over 120 municipalities, sharing best practices in energy efficiency with public institutions, and undertaking detailed energy audits at bulk water supply systems in seven large cities in Karnataka.

The EMC has also championed the cause of effective energy management by lobbying the Government of Karnataka to make energy efficiency one of KUIDFC's mandates. For the last year, EMC has been creating awareness on energy savings opportunities within various government departments such as Finance, Energy, and Reforms with the ultimate objective of receiving their approval to initiate the issuance of a Government Order for implementing energy efficiency programs in municipalities statewide. This unprecedented Government

Order will be a landmark among state government energy policies in India, promoting the devolution of fiscal authority and the public-private partnerships for effective municipal energy management.

The EMC has also been instrumental in highlighting the benefits of Carbon Trading to the Government of Karnataka. Persuaded largely by the EMC's efforts, KUIDFC has signed a letter of intent with the World Bank for selling Certified Emission Reductions achieved by the implementation of energy efficiency measures in bulk water supply systems at six municipalities.

F. Lessons Learned on Effective Watergy Approaches

The success or failure of energy efficiency measures in municipal water systems can depend greatly on the management model in place to develop and implement the measures. Based on more than a decade of experience with municipal water utilities, the Alliance to Save Energy has found that a team management approach, based in part on corporate energy management programs long used by private sector companies, provides the best opportunity to enact long-term energy efficiency improvements across the entire organization.

Some water utilities have implemented water and energy efficiency measures on ad hoc basis, reacting to specific problems without a comprehensive management plan. These utilities often lack the institutional capacity and/or the commitment to implement the vast majority of efficiency opportunities. New energy and water projects are often implemented without consciously addressing efficiency and are unlikely to be proactively linked with other efforts to maximize savings. The ad hoc approach is characterized by a scarcity of water and energy use data, lack of coordination among various departments, and limited capital allocation to efficiency projects. Top managers do not focus on energy and water efficiency and do not assign resources to this purpose.

Other utilities may choose to appoint an individual to address specific concerns, such as pump efficiency, water conservation, or wastewater treatment. In many cases, the creation of a dedicated efficiency manager is a positive step in addressing key energy and water efficiency issues. An efficiency manager focused on a single issue can deliver significant savings to the utility, can stimulate increased levels of data collection and sharing, and can help other departments improve their efficiency focus. The appointment of an efficiency manager, however, does not go far enough in bringing together all the resources required to maximize water and energy efficiency. The efficiency manager approach may not increase the involvement of key staff members in the efficiency process, and may not stimulate the comprehensive effort by multiple departments and staff needed to achieve the greatest savings. Some common complaints from efficiency managers employed in this type of system include insufficient control over resources and other staff's time; limited interaction, planning, and coordination among various departments; and lack of buy-in and coordination among departments for efficiency projects.

In contrast, the team management approach involves the entire organization in a systematic effort to improve energy efficiency. This approach requires strong advocates or

"champions" at the senior and middle management levels. Senior managers identify comprehensive water and energy efficiency as a core function of the water authority and ensure that appropriate resources are dedicated to achieving this goal. Middle-level managers provide the day-to-day leadership and incorporate energy efficiency into water system management duties. Watergy efficiency teams can mobilize a wide variety of resources and staff to improve communication throughout the company. In addition, teams are able to streamline efficiency project identification and implementation and ensure the coordination of activities. A functioning team will make water and energy efficiency part of the core business of the water utility.

The team management approach is based on Corporate Energy Management Programs (CEMP), adopted by many large manufacturing companies to reduce operating costs well below their competitors through energy efficiency savings. A key lesson of CEMP systems for efficiency teams is that continuous improvement requires a management structure that combines the technical aspects of energy efficiency with effective operational management, to ensure that the initial efficiency gains from technical innovation are sustained and incorporated into the company's long-term operating practices.

The Alliance to Save Energy has found the following key components of CEMP to be essential for creating a successful Watergy efficiency management program:

❶ Commitment by top-level management.

❷ Clearly defined energy reduction goals.

❸ Communication of the goals throughout all levels in the company.

❹ Assignment of project responsibility and accountability at the proper level.

❺ Formulation and tracking of energy use metrics.

❻ Identification of all potential projects on a continuous basis.

❼ Adoption of project investment criteria, reflecting project risks and returns.

❽ Provision of recognition and reward for achieving the goals.

XII. ANNEX 3: Government and World Bank Programs to Fund Energy Efficiency

A. World Bank

Energy Sector Management Assistance Programme (ESMAP)

The World Bank's Energy Sector Management Assistance Programme (ESMAP) provides technical assistance and policy advice to governments in pursuit of sustainable energy development. In the 1990s ESMAP and the European Union began facilitating the transfer of performance-based energy management techniques to prospective market economies in Latin America. In Brazil, the World Bank worked with municipal utilities in the states of Tocantins and Rio de Janeiro to implement Energy Monitoring and Target Setting (EM&T). Under EM&T, utilities learned how to manage energy use more effectively by analyzing energy use at each point in the water service provision process and setting targets for improving energy efficiency at each point of accountability. In one test case, the utility serving the city of Petrópolis, Rio de Janeiro State, is using EM&T to identify and implement measures that should reduce its energy expenditures by more than 50 percent through investments in micro-hydropower, installing meters, and retrofitting pipelines and other key pieces of infrastructure.

B. Brazil

Brasil Joga Limpo (Brazil Plays Clean)

- A program of the federal government within the scope of the National Environment Policy, which has a set of criteria governing the *Fundo Nacional do Meio Ambiente* - FNMA (National Fund for the Environment).
- Administered with resources from the General Budget of Brazil (OGU), transferred to the municipalities and state and municipal concessionaires as soon as agreements are finalized.

FCP-SAN – Financing Program for Private Sanitation Services Concessionaires

- Creates financing possibilities for private water and sewerage services concessionaires, to make the investments necessary to operate systems in the manner set forth in the concession contract.
- Water supply and sewerage projects might include development of studies and technical projects, acquisition of materials and equipment, products and services, or exploration for new water sources. Projects for operational improvements and reduction of costs and losses are also acceptable under this fund.
- The resources for application within the scope of FCP/SAN come from the FGTS, Sanitation section, part of the Plan for Contracting and Physical Goals, and the *Banco Nacional de Desenvolvimento Econômico e Social* (BNDES), through the program BNDES AUTOMÁTICO.

Water Resources Management Program

- A federal government program that integrates projects and activities focused on the recovery and preservation of the quality and quantity of water resources in hydrographic basins.
- Operated with funds from the General Budget of Brazil, which are transferred to the states, federal district and municipalities as the requirements of the different project stages are executed and verified. The funds are deposited into a specific account opened at a branch of the CEF exclusively for transferring amounts related to the execution of the purpose of the signed contract.

Living Better Program (Morar Melhor)

- Promotes integrated actions for urban development in the regions with the highest concentration of poverty in the country. The program has goals of achieving universal service coverage for basic and environmental sanitation, expanding the supply of shelter and promoting improved living conditions and urban infrastructure, focusing on areas with a fragile economic base.
- The funding mechanism is the same as that described for the Water Resources Management Program above.

PASS/IBD – Program for Social Action in Sanitation

- Implements integrated sanitation projects in poverty-stricken areas, providing universal service coverage for water supply and sewerage in the areas with the largest concentration of poverty.
- Municipalities with urban population between 15,000 and 50,000 inhabitants and those with a deficit in coverage of water supply services above the national average are eligible for this program.
- The program anticipates activities in pre-investment (project conception studies, basic and executive projects, EIA/RIMA and sanitary education), institutional development and sanitary and environmental education, with the Ministry of Cities as the administrator.
- Although the program has not yet been approved by the IBD, the funds already directed towards basic and executive projects, EIA/RIMA,, originated from the General Budget of Brazil – OGU, from state co-funding and from the extinct PROSEGE - *Programa Emergencial de Geração de Emprego em Obras de Saneamento* (Emergency Program for Generation of Employment in Sanitation Projects).

Project for Technical Assistance for Sanitation Programs for Populations in Low-Income Areas (PAT - PROSANEAR/IBRD)

- The resources destined for PAT PROSANEAR are US$ 49 million, US$ 30 million from the International Bank for Reconstruction and Development (IBRD) and US$ 19.0 million in non-financial co-funding from the federal government and the recipient utilities. Of the total of US$ 30 million, 28.4 million will be spent on consulting and training services. The largest portion of the funds (about US$ 21 million) will be used in the pre-

investment section to finance development of integrated sanitation projects and the local integrated development plans.

- Provides technical and financial support to states, federal district, municipalities and sanitation service providers under Ministry of Cities management for the development of *Planos de Desenvolvimento Local Integrado* – PDLI (Local Integrated Development Plans), and *Projetos de Saneamento Integrado* – PSI (Integrated Sanitation Projects).

Program for Modernization of the Sanitation Sector – Second Stage (PMSS II – IBRD)

- The PMSS II projects spend a total of US$ 211 million, through three agreements: US$ 130 million from the contract with the IBRD, of which US$ 75 million is raised by the CEF; US$ 30 million from the BNDES and US$ 25 million, already contracted with the Special Secretary of Urban Development – SEDU/PR (Ministry of Cities); and US$ 81 million from local co-funding.
- Begun in 1993 as a pilot project, PMSS I, generally focused on modernization of the sanitation sector, seeking improved efficiency and increased capacity to finance service performance. This led to universal service coverage for the entire population in the pilot area, particularly the poorest sections.
- The federal government will assume the credit risk of operations of PMSS II, per the agreement signed with the IBRD. In the credit operations between the CEF and the sanitation companies, arising from the agreement to be signed directly with the IBRD, through an Authorizing Law from the federal government, or in its absence, the states and municipalities will provide a guaranty to the operation.

Pró-Saneamento

- Promotes improved health conditions and quality of life to the population, through sanitation activities integrated and articulated with other sector policies.
- Types of programs include projects that increase coverage and/or production capacity of water supply systems water supply or increase coverage of sewerage systems and/or adequate treatment and disposal of effluents.
- The program is implemented by means of a financing concession to the states, federal district, municipalities or non-dependent state companies. FGTS is the source of funds.

Financing with BNDES Resources

- To participate in the program, the interested party must present a proposal accompanied by the basic documentation required by the CEF. Once the proposal is registered, the interested party must present economic-financial documentation, and engineering and legal aspects for feasibility analysis.
- Funding from BNDES is automatic. The minimum value of the co-funding is 40%.

C. Mexico

Programa de Acciones de Saneamiento (PAS) (Sanitation Action Program)

- Cancellation and exemption from the payment of taxes for using or exploiting national waters and for using or exploiting public domain goods such as receiving bodies for wastewater discharges.

Programa de Agua Potable, Alcantarillado y Saneamiento en Zonas Urbanas (APAZU) (Drinking Water, Wastewater and Sanitation Program in Urban Areas)

- Federal resources allotted for the year 2003 reached US$ 86.6 million, which combined with the local and state contributions of US$ 119.6 million, made a total investment of US$ 206.25 million, as shown in **Table XV**. With these resources, approximately 207 thousand drinking water service additions and 2.6 million service improvements were made. In addition, around 141,000 people were provided with sewage system service and the service of 1.6 million people was improved. Wastewater treatment was increased by 923 liters per second.

Table XV. Public Funding for Drinking Water Sector in Mexico[37]

Source	FEDERAL	STATE	MUNICIPAL	TOTAL
Amount (million US$)	86.64	59.805	59.805	206.25

- In order to reach towns with a population of 2,500 inhabitants or more, the CNA has been operating this program since 1990. The program's financing comes from a mixture of federal, state, credit and utility resources. Definitions of the actions and financial structures are agreed upon by the Special Water Subcommittee of the State Planning and Development Committees. With the APAZU, expansion of the infrastructure and execution of actions for institutional improvement and increased efficiency are supported, derived from a master plan designed for the utility.

Programa de Atención a la Frontera Norte: Programa Demostrativo de Desarrollo Institucional en Agua Potable y Saneamiento (PRODDI) (Demonstration Program for Institutional Development in Drinking Water and Sanitation)

- Investments totaling US$ 99 million were made, representing an increase of 100% in comparison to 2002. The main sources of financing have come from the federal government (US$ 30 million), state contributions (US$ 36 million), town councils (US$ 13 million), Banco Japonés, and U.S. EPA funds (US$ 13.5 million).
- This program was developed to deal with the commitment between the United States and Mexico to generate environmental alternatives for border towns. Actions have been taken to increase drinking water, wastewater and sanitation coverage, to contribute to health care, the quality of life of the population, the development of communities and to prevent environmental degradation.

[37] Distribution of resources from the APAZU program, 2003; Source: Situation of the drinking water, wastewater and sanitation sub-sector as of December 2003, CNA.

Programa Demostrativo de Desarrollo Institucional en Agua Potable y Saneamiento (PRODDI) (Demonstration Program for Institutional Development in Drinking Water and Sanitation)

- This program supports the modernization and reform process of the drinking water and sanitation sub-sector in Mexico, introducing actions for utilities that promote their administrative autonomy, operating efficiency, and equality in access to service, as well as encouraging public participation and promoting financial sustainability.
- Financed in part with resources from the Inter-American Development Bank (IDB). The program was started through pilot projects in five small municipalities.

Programa de Devolución de Derechos (PRODDER) (Tax Return Program)

- To increase the sources of financing that support actions to improve efficiency and infrastructure for drinking water, sewerage and wastewater treatment.

Programa para la Modernización de los Organismos Operadores de Agua (PROMAGUA) (Water Utility Modernization Program)

- The purpose of this program is to provide additional resources, conditional on a structural change scheme to promote the consolidation of water utilities that serve more than 50,000 inhabitants; to promote their physical and commercial efficiency; to facilitate access to leading-edge technology; to promote self-sufficiency; and to promote environmental awareness in sanitation projects, preferably related to reusing wastewater, with participation of the private sector.

Programa de Saneamiento del Valle de México (Valle de México Sanitation Program)

- With an investment of US$ 31 million in 2003, the construction of drainage improvement projects has begun.
- The main purpose of this program is to support governments of the *Distrito Federal* and the State of Mexico to increase the supply of water from external sources, to guarantee adequate supply and distribution, and to find a solution integrated to the removal and treatment of wastewater from the metropolitan area of the Valle de México, as well as to reduce the vulnerability of Mexico City's population to the risk of flooding.
- Trust established with the *Banco Nacional de Obras* (BANOBRAS)

Programa para la Sostenibilidad de los Servicios de Agua Potable y Saneamiento en Comunidades Rurales (PROSSAPYS) (Drinking Water and Sanitation Services Sustainability Program in Rural Communities)

- Projects in 2003 represented investments of US$ 97 million in addition to the US$ 5.07 million credit granted by the IDB.
- The CNA has been implementing this program since 1996 in rural areas with populations of less than 2,500 with equal contributions from federal and state governments.
- In 2003, 432 drinking water systems and 139 sewage systems were built and 8,136 rural sanitation systems were installed, 23 drinking water systems and two sewage systems

were rehabilitated, and 618 studies and projects were completed for future construction. As of 1999, the contribution has been partially financed with credit resources from the Inter-American Development Bank.