WATER SUPPLY AND SANITATION SECTOR BOARD DISCUSSION PAPER SERIES

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DECEMBER 2006

The Challenge of Reducing Non-Revenue Water (NRW) in Developing Countries

How the Private Sector Can Help: A Look at Performance-Based Service Contracting

Bill Kingdom, Roland Liemberger, Philippe Marin

THE WORLD BANK GROUP

Water Supply & Sanitation Sector Board

PPIAF
PUBLIC-PRIVATE INFRASTRUCTURE ADVISORY FACILITY

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DISCLAIMERS

CONTACT INFORMATION

Bill Kingdom, Lead Water and Sanitation Specialist, World Bank: wkingdom@worldbank.org, tel. 202-473-9093

Philippe Marin, Senior Water and Sanitation Specialist, World Bank: pmarin@worldbank.org, tel. 202-458-7761

Roland Liemberger, Founder, Liemberger & Partners GmbH: roland@liemberger.cc, tel. +43-463-500-577

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ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
avg.	average
AWWA	American Water Works Association
BOT	build-operate-transfer
CE	compensation event
CIS	Commonwealth of Independent States
conn.	connection
DMA	district metering area
DoE	Department of the Environment
EWD	Energy and Water Department (World Bank)
IBNET	International Benchmarking Network for Water and Sanitation Utilities
ILI	Infrastructure Leakage Index
IWA	International Water Association
km	kilometer
l	liter
m	meter
m3	cubic meter
MDG	Millennium Development Goal
MWA	Metropolitan Waterworks Authority (Bangkok)
NRW	non-revenue water
NWC	National Water Council
OBA	output-based aid
PPIAF	Public-Private Infrastructure Advisory Facility
PPP	public-private partnership
R$	reais (Brazil)
SABESP	Companhia de Saneamento Básico do Estado de São Paulo
SEAWUN	South East Asian Water Utilities Network
US$	dollars (United States)
WAA	Water Authorities Association (United Kingdom)
WHO	World Health Organization
WRc	Water Research Centre

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EXECUTIVE SUMMARY

One of the major issues affecting water utilities in the developing world is the considerable difference between the amount of water put into the distribution system and the amount of water billed to consumers (also called "non-revenue water" [NRW]). High levels of NRW reflect huge volumes of water being lost through leaks, not being invoiced to customers, or both. It seriously affects the financial viability of water utilities through lost revenues and increased operational costs. A high NRW level is normally a surrogate for a poorly run water utility that lacks the governance, the autonomy, the accountability, and the technical and managerial skills necessary to provide reliable service to their population.

The waste of resources resulting from high NRW levels in developing countries is considerable. To illustrate this point, the study begins with a global overview of the situation and what it means in terms of foregone services to new consumers and the financial costs to utilities. The total cost to water utilities caused by NRW worldwide can be conservatively estimated at $14[1] billion per year, with a third of it occurring in the developing world. In developing countries, about 45 million cubic meters are lost daily through water leakage in the distribution networks—enough to serve nearly 200 million people. Similarly, close to 30 million cubic meters are delivered every day to customers, but are not invoiced because of pilferage, employees' corruption, and poor metering. All this directly affects the capacity of utilities in developing countries to become financially viable and fund necessary expansions of service, especially for the poor.

Although it is not feasible to eliminate all NRW in a water utility, reducing by half the current level of losses in developing countries appears a realistic target. This reduction could generate an estimated additional $2.9 billion in cash every year for the water sector (from both increased revenues and reduced costs) and potentially service an additional 90 million people without any new investments in production facilities nor drawing further on scarce water resources. Figures of such magnitude, even though they are based on a rough estimate, should obviously capture the attention of donors and developing-country governments alike.

If the reasons for reducing levels of NRW are so compelling, then why hasn't this widespread and generally well-understood challenge already been tackled and defeated? The reason is that reducing NRW is not just a technical issue but also one that goes to the heart of the failings of public water utilities in developing countries. These water utilities often operate under a weak governance and financial framework, with utility managers having to face multiple political and economic constraints. They have to provide some form of service to customers on a daily basis with mostly deteriorated infrastructure. In addition, they often lack the proper incentives—as well as the specialist management and technical expertise—necessary to carry out an effective NRW program. This is where the private sector could be of assistance, and a wide range of options are available, ranging from delegated management contracts at one extreme (that is, public-private partnerships [PPPs] such as concessions, leases/affermages, or management contracts) to service contracts, limited subcontracting of specific activities, or both, at the other.

1. All dollar amounts are in U.S. dollars unless otherwise indicated.

Although there have been many PPP projects during recent decades in developing countries that have led to notable improvements in NRW levels, the overall experience with service contracts designed mostly around technical assistance has been disappointing. This study argues that short of delegated management to the private sector (through a management contract, lease, or concession), a new alternative for private sector involvement, performance-based service contracting, holds good potential in the context of developing countries for reducing NRW levels. Under performance-based service contracting, a private company is contracted by the management of a public utility to carry out a comprehensive NRW reduction program, with sufficient incentives and flexibility to ensure accountability for performance and with payment linked to actual results achieved in NRW reduction. Such an approach could be especially attractive in situations where the government has decided to keep the water utility under public management, but is looking for ways to capitalize on the technical expertise and potential efficiency of the private sector.

In this report, a number of case studies, taken from some of the largest and most recent performance-based NRW contracts, are studied and discussed in terms of their technical and financial performance. Lessons learned from the case studies are analyzed, showing the potential benefits of NRW performance-based service contracting with the private sector. Although performance-based service contracting for NRW reduction is a new approach and none of the contracts reviewed could be described as "best-practice", these early experiences hold useful lessons for water practitioners. The limited evidence available suggests that performance-based service contracting can be very efficient in reducing NRW levels. It is based on a more efficient contractual framework than the traditional technical assistance approach, with the private sector being accountable for results through financial incentives, while having at the same time the necessary flexibility and resources to carry out the many activities needed to make a meaningful impact on NRW levels.

The driving factor when designing a performance-based service contract for NRW reduction is to establish an incentive framework that encourages the private sector to deliver results in the most cost-effective manner and allocates risk appropriately between the parties. Key lessons from the cases reviewed include the need to leave sufficient flexibility to the private partner, to set appropriate and realistic targets, and to limit cost pass-through items. A fundamental design issue is the level of performance risk to be transferred to the private partner (that is, how much of the contract value is paid through results-based incentives, as opposed to fixed payments). This is linked to the level of risks that the private sector would be willing to take; in the case studies analyzed in this report, only a portion of the revenues of the private partner was paid via variable incentives. In the context of most water utilities in the developing world, the challenge will be to find a balance between accountability for end results on one side and a cost-effective level of risk transfer to the private sector on the other side.

It is often stated that NRW reduction activities have a quick payback. Although this can often be true and is most often the case for the reduction of commercial losses, another important issue illustrated by the case studies is that reducing physical leakages can require significant capital investment. The performance-based service contracts to reduce physical losses presented in this paper all included significant budgets for investment and field work, such as leak repairs and meters/valves installation. Data from the limited set of projects available suggest that in developing countries, the unit cost of reducing physical leakage would be in the range of $215 to $500 per cubic meter saved on a daily basis, with a unit cost of around $250 per cubic meter per day probably achievable for the most efficient projects. In any case, a detailed cost-benefit analysis should always be undertaken early to ensure that any proposed NRW reduction program makes financial sense, given the value of water saved (marginal cost or revenue per cubic meter saved) and the cost of developing alternative production sources.

Finally, and despite its obvious potential, it is worthwhile to keep in mind that performance-based service contracting for NRW reduction should not be viewed as a new magic formula for solving the many woes of public water utilities in developing countries, which come from more fundamental institutional problems. It does, however, have the potential to bring some rapid improvements for a public water utility, in terms of both increased cash flows and more water available to serve the population, by efficiently harnessing the know-how of the private sector. Nothing works like success, and by demonstrating that things can be improved, a successful performance-based service contract for NRW reduction can create a positive dynamic for change within the utility and the sector as a whole. This could in turn generate enough momentum to push for the institutional and governance reforms that are necessary to establish sustainable public water utilities so that they can more effectively serve the need of the growing population in developing countries.

THE CASE FOR NON-REVENUE WATER REDUCTION

Before discussing the potential of performance-based service contracting to reduce the significant levels of non-revenue water (NRW) in developing countries, it is important to broadly set NRW in context. This short section outlines the scale, cost, and sources of NRW and the myriad of reasons why, despite the obvious benefits of NRW reduction, levels remain so high. It is against this backdrop that the need to seek new ways of addressing the problem becomes so obvious; hence, the investigation of performance-based service contracting as one such approach.

What Is Non-Revenue Water?

Non-revenue water is the difference between the volume of water put into a water distribution system and the volume that is billed to customers. NRW comprises three components: physical (or real) losses, commercial (or apparent) losses, and unbilled authorized consumption.

- **Physical losses** comprise leakage from all parts of the system and overflows at the utility's storage tanks. They are caused by poor operations and maintenance, the lack of active leakage control, and poor quality of underground assets.
- **Commercial losses** are caused by customer meter under registration, data-handling errors, and theft of water in various forms.
- **Unbilled authorized consumption** includes water used by the utility for operational purposes, water used for firefighting, and water provided for free to certain consumer groups.[2]

How Much Water Is Lost?

Although it is widely acknowledged that NRW levels in developing countries are very high, in fact, very few data are available in the literature regarding the actual figures, largely because most water utilities in the developing world do not have adequate monitoring systems for assessing water losses and many countries lack national reporting systems that collect and consolidate information on water utility performance. The result is that NRW data are usually not readily available, and when they are, they are not always reliable because it is common for the management of poorly performing utilities to practice "window dressing" in an attempt to conceal the extent of their own inefficiency.

A recent report[3] by the Asian Development Bank (ADB) mentions a study performed by the South East Asian Water Utilities Network (SEAWUN) analyzing NRW levels of 47 water utilities across Indonesia, Malaysia, Thailand, the Philippines, and Vietnam, which concluded that the levels of NRW average 30 percent of the water produced, with wide variations among individual utilities ranging from 4 percent to 65 percent.

2. Contrary to physical and commercial losses, unbilled authorized consumption does not reflect operational inefficiencies, but rather a public policy decision to allocate water without monetary compensation.

3. "Nonrevenue Water: A Governance Challenge," ADB, October 2006. http://www.adb.org/water/topics/non-revenue/default.asp.

The World Bank database on water utility performance (IBNET, the International Benchmarking Network for Water and Sanitation Utilities, at www.ib-net.org) includes data from more than 900 utilities in 44 developing countries. The average figure for NRW levels in developing countries' utilities covered by IBNET is around 35 percent. Source: IBNET

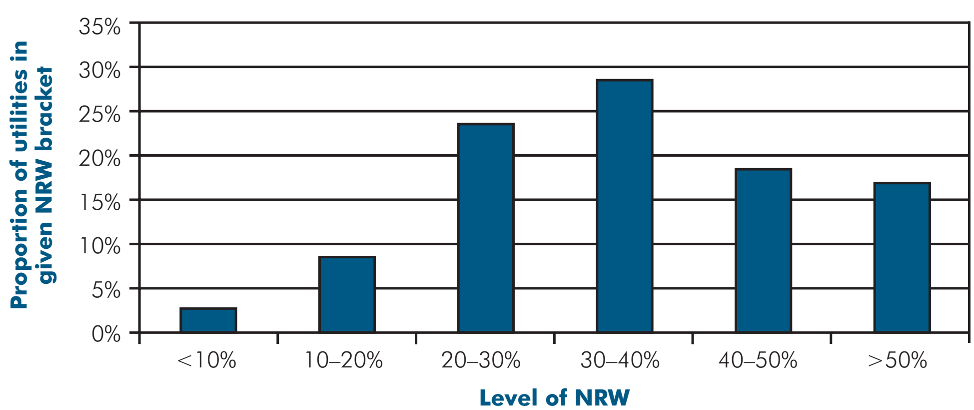
Figure 1 shows the distribution of the level of NRW among the utilities covered by IBNET.

It is likely that the above 35 percent figure is less than the global NRW level in the developing world because large developing countries with known high levels of NRW are still not covered by IBNET and the utilities that report operating data tend to be the ones with the better performance levels, while the worst-performing utilities rarely report data or, if they do, the information is not reliable. The actual figure for overall NRW levels in the developing world is probably more in the range of 40–50 percent of the water produced.

Table 1 shows an estimate of the worldwide volume of NRW in urban water supply systems and a breakdown by components. The population figures were taken from the World Health Organization's (WHO's) update on the Millennium Development Goals (MDGs), and a conservative estimate of 35 percent for NRW in developing countries was used (the average figure available from IBNET). Other assumptions on per capita consumption, the levels of NRW, and the percentage breakdowns of losses are based on the authors' experience.

The result is quite staggering. Every year, more than 32 billion cubic meters of treated water physically leak from urban water supply systems around the world, while 16 billion cubic meters are delivered to customers for zero revenue. Half of these losses are in developing countries, where public utilities are starving for additional revenues to finance expansion of services and where most connected customers suffer from intermittent supply and poor water quality.

Figure 1. NRW Performance of Utilities in IBNET Database



Source: IBNET.

Table 1: Estimates of Worldwide NRW Volumes

			ESTIMATES OF NRW					
				Ratio		Volume (billions of m^3/year)		
	Supplied population (millions, 2002)	System input l/capita/ day	Level of NRW (% of system input)	Physical losses (%)	Commercial losses (%)	Physical losses	Commercial losses	Total NRW
Developed countries	744.8	300	15	80	20	9.8	2.4	12.2
Eurasia (CIS)	178.0	500	30	70	30	6.8	2.9	9.7
Developing countries	837.2[a]	250[b]	35	60	40	16.1	10.6	26.7
			TOTAL			32.7	15.9	48.6

Sources: WHO and authors' estimates.

l = liters; m^3 = cubic meters

a. Based on a total population having access to safe water supply of 1,902.7 million people, with 44 percent of these receiving water through individual household connections.

b. This figure reflects actually a wide discrepancy among developing countries, from 100 l/capita/day for some utilities in the poorest countries or those experiencing severe water shortages to more than 400 l/capita/day in many megacities of Latin America and East Asia. The figure used in this calculation is a conservative average.

How Much Does It Cost?

The cost of these water losses is enormous when taken worldwide.

Table 2 shows some simple assumptions from which the value of lost water can be calculated. Physical losses were valued at the marginal cost of water, and commercial losses were valued by using the average tariff. For developing countries, $0.20 and $0.25 were used for the marginal cost and average tariff, respectively.

This calculation suggests that more than US$14 billion is lost every year by water utilities around the world—and more than a third of that by water utilities in developing countries.[4] Although the hypothesis behind these calculations could be modified,[5] the scale of the problem is obvious and cannot be ignored.

It is particularly noteworthy that the estimate of what is lost every year in developing countries through commercial losses (that is, water that is actually delivered to a portion of the population, but not invoiced) is estimated at US$2.6 billion. This is approximately a quar-

4. To put this into perspective: it is estimated that around US$20 billion must be invested every year to reach the MDGs for basic access to potable water in developing countries.

5. The hypotheses used for this calculation are conservative: most water utilities in developing countries have NRW that exceeds 50 percent, and the true marginal cost of water will often exceed US$0.20 /cubic meter.

Table 2: Estimated Value of NRW and Its Components

	Marginal cost of water (US$/m³)	Average tariff (US$/m³)	(Estimated values, billions of US$/year) Cost of physical losses	Lost revenue resulting from commercial losses	Total cost of NRW
Developed countries	0.30	1.00	2.90	2.40	5.30
Eurasia (CIS)	0.30	0.50	2.00	1.50	3.50
Developing countries	0.20	0.25	3.20	2.60	5.80
		TOTAL	8.10	6.50	14.60

Source: Authors' calculations.
m^3 = cubic meters

ter of the total yearly investment in potable water infrastructure for the entire developing world. It is also more than the World Bank (the largest water financier among international financial institutions) lends every year in aggregate for water projects in developing countries. That (in practice) a sizable portion of this commercial loss is likely to come from fraudulent activities and corruption (such as illegal connections, fraudulent meter readings, or meter tamperings) should be cause for concern for both developing countries' governments and the donor community alike. At a minimum, some further analysis should be considered to confirm the scale and source of these commercial losses.

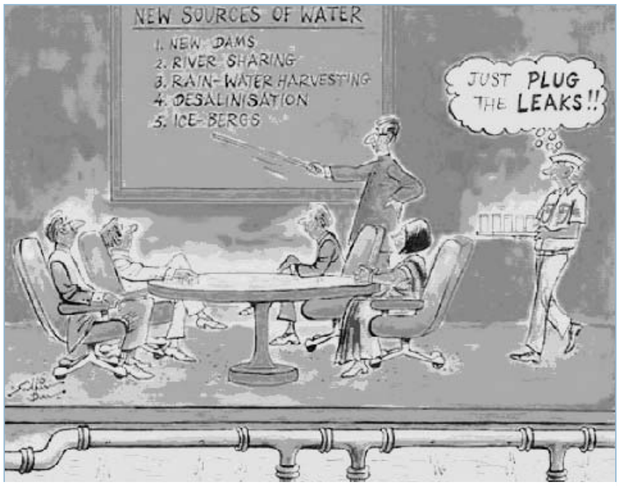
What Are the Benefits from Reduced NRW?

It is not realistic to expect water utilities to eliminate all commercial and physical losses. However, in developing countries, it is certainly not unrealistic to expect that the high levels of physical losses could be reduced by half. Based on the above example, this would provide 8 billion cubic meters per year of already treated water—enough water to service an additional 90 million[6] people who currently lack access to piped water and to save an estimated US$1.6 billion[7] per year in production and pumping costs for public utilities. Similarly, if commercial water losses in developing countries could be cut by 50 percent, then another US$1.3 billion in additional revenues could be generated each year.

Thus, reducing NRW to just half the current level in the developing world—a reasonable objective—would deliver the following benefits:

6. Based on the assumption of 250 liters per capita per day system input.

7. Assuming 35 percent NRW.



Source: Water and Sanitation Program of the World Bank.

- Eight billion cubic meters of already treated water would be available to service customers.
- Ninety million more people could gain access to water supply, without increasing demand on endangered water resources.
- Water utilities would gain access to an additional US$2.9 billion in self-generated cash flow, equivalent to more than a quarter of the amount currently being invested in water infrastructure in the developing world, and this without affecting in any manner the debt capacity of those countries.
- Fairness would be promoted among users by acting against illegal connections[8] and those who engage in corrupt meter-reading practices.
- Consumers would have improved service delivered by more-efficient and more-sustainable utilities.
- More economic growth with new business opportunities would be created for NRW reduction activities, with thousands of jobs created to support labor-intensive leakage reduction activities.

In practice, these potential benefits should be considered on a case-by-case basis against the actual cost of implementing a water losses reduction program. In the case of commercial losses, the execution of a loss reduction program is likely to be financially beneficial, with short payback periods. In the case of physical loss reduction, the key issue is deciding on the appropriate level of loss reduction and its related investment. In developing-country utilities, with high levels of physical losses, there will be a good financial case for initial loss reduction by picking many of the “low-hanging fruit,” which can provide short payback periods. As these low-hanging fruit disappear, the cost of reducing physical losses will rise.

Whether for commercial or physical loss reduction, therefore, a cost-benefit analysis must be carried out, comparing the unit cost of saving water from network leakage with the value of the water saved. There are a number of well-written documents on this subject from which readers can find further guidance.[9]

Non-Revenue Water: The Technical Issues

Although the above-mentioned global costs and scale of NRW may not have been so starkly presented before, the technical issues surrounding NRW have been written about extensively (albeit much of the writing coming from the United Kingdom and the

8. This does not rule out, of course, subsidies targeted at the poor, when necessary.

9. For example: D. Pearson and S. Trow, “Calculating Economic Levels of Leakage,” Conference Proceedings, International Water Association (IWA) Leakage 2005 Conference in Halifax, Nova Scotia, Canada (download from http://waterloss2007.com/Leakage2005.com/index.php); also “Leakage Control Policy and Practice,” DoE/NWC (Department of the Environment/National Water Council), reprinted by WAA/WRc (Water Authorities Association / Water Research Centre), Report 26 (1980, 1985)

International Water Association [IWA] in the 1980s and 1990s). In addition, these technical issues are discussed widely, with regular NRW conferences and workshops around the world. A short summary of the key technical issues related to NRW are therefore presented in appendix to provide readers with a quick overview of the subject, with a focus on the following:

- The need to know the causes and *quantities* of the various components of NRW. Particular reference is made to the use of a standard water balance (as developed by the IWA). No proper NRW reduction strategy can be planned without the quantification of physical and commercial losses.
- The selection of appropriate NRW performance indicators. The *inherent weakness* in using percentage of NRW is discussed. Liters per connection per day (in combination with taking supply time and pressure into account) is the preferred measure for physical losses; commercial losses are best expressed as percentage of authorized consumption.
- The core components of a cost-effective NRW reduction strategy. Options to address physical and commercial losses are separately presented.

Why Do Utilities Struggle with NRW Reduction?

In spite of the potential benefits, NRW reduction is not a simple matter to implement, and this explains why so many water utilities fail to address this issue effectively. Not only do new technical approaches have to be adopted, but effective arrangements must be established in the managerial and institutional environment—often requiring attention to some fundamental challenges in the utility.

Understanding the Problem

Not understanding the magnitude, sources, and cost of NRW is one of the main reasons for insufficient NRW reduction efforts around the world. Only by quantifying NRW and its components, calculating appropriate performance indicators, and turning volumes of lost water into monetary values can the NRW situation be properly understood and the required action taken. It is noteworthy that despite the fact that many utilities in the developing world have implemented NRW reduction programs with donor funding, it is rare that a comprehensive water balance, as described in appendix 1, was actually developed and calculated. It is no wonder, therefore, that the end results often fail to match expectations.

NRW management is not technically difficult, but it is complex. Properly understanding the baseline situation is a critical first step in moving toward an effective reduction program.

Lack of Capacity

NRW requires a range of skilled staff, including managers and professional engineers at one end of the spectrum right through to street crews, technicians, and plumbers at the other. "NRW reduction," in its broadest sense, is not taught at universities or technical colleges nor in many of the water industry training institutions around the world. As a consequence, staff with necessary skills are not widely available. Addressing this issue will require both an acceptance of the widespread challenges and consequences associated with NRW and then the development of appropriate training materials, methods, and institutions. A major initiative is required to build such capacity.

Missing Management Focus

Establishing and maintaining an effective NRW program is, besides all other difficulties, a managerial problem.

Physical loss reduction is an ongoing, meticulous activity with few supporters among the following:

- Politicians: there is no "ribbon cutting" involved.
- Engineers: it is more "fun" to design treatment plants than to fix pipes buried under the road.
- Technicians and field staff: detection is done primarily at night, and pipe repairs often require working in hazardous traffic conditions.
- Managers: it needs time, constant dedication, staff, and up-front funding.

Nor is the reduction of commercial losses very popular among the following:

- Politicians: unpopular decisions might have to be made (disconnection of illegal consumers or customers who don't pay).
- Meter readers: fraudulent practices might generate a substantial additional income.
- Field staff: working on detecting illegal connections or on suspending service for those who don't pay their bills is unpopular and can even be dangerous.
- Managers: it is easier to close any revenue gap by just spending less on asset rehabilitation (letting the system slowly deteriorate) or asking the government for more money.
- Except for those customers who do pay their bills, it might appear that there is no support from any party.

Given this situation, a utility manager trying to establish an NRW program to reduce high levels of losses may face frustrating responses from his or her own staff and from the utility owners. Engineers and operational staff will assure him or her that the levels relate solely to commercial losses (that is, there is no leakage problem), while the commercial staff will say that it is all leakage.

Importance of Enabling Environment and Incentives

Most of the above challenges can and do apply to both private and public utilities, but (in general) private operators have incentives to reduce NRW because this can generate more revenues and reduce operating costs, in addition to specific contractual targets in several cases.[10,11] It is, however, more difficult for publicly managed utilities because they often lack an adequate enabling environment and a proper incentive framework for performance.[12] Recent findings suggest, however, that the right incentives can be put in place in a public utility within a broader framework of encouraging autonomy, accountability, and market and customer orientation.[13] Although the topic of how to make a public utility

10. Clarissa Brocklehurst and Jan Janssens, "Innovative Contracts, Sound Relationships: Urban Water Sector Reform in Senegal," Water Supply and Sanitation Sector Board Discussion Paper 1, January 2004, World Bank, Washington, DC.
11. Klas Ringskog, Mary-Ellen Hammond, and Alain Locussol, "The Impact from Management and Lease/Affermage Contracts," PPIAF, 2006.
12. For instance, a lack of flexibility in human resources management could make it difficult to reorganize working shifts and pay bonuses for staff who work at night on leakage detection.
13. Aldo Baietti, William Kingdom, and Meike van Ginneken, "Characteristics of Well-Performing Public Water Utilities," Water Supply and Sanitation Working Notes 9, February 2006, World Bank, Washington, DC.

more efficient is beyond the scope of this paper, improving NRW performance is clearly a major outcome that would be desired from such an initiative.

It is instructive to consider the incentives related to NRW programs in a little more detail and wonder why, despite the obvious benefits of NRW reduction, the NRW performance of utilities in the developing world is so poor. A commonly voiced answer is that politicians are mostly interested in "ribbon cutting," and so it is easier for the utility management to obtain support for a new water treatment plant than for a leakage reduction program.

The reality, as usual, is more complex. Such explanation fails to account for the fact that implementing a NRW reduction program is inherently complex. It requires addressing, in a comprehensive manner, the various problems that lie at the root of the poor performance of a water utility. This represents a challenge that goes beyond just NRW performance. It should come as a surprise to no one that both politicians and utility management see investments in NRW reduction as risky because they feel uncertain that the expected benefits can be realized. Because civil servants tend to be risk-averse, it is therefore logical that when confronted with a choice between reducing NRW and increasing production capacity, they choose the second solution. This might not make much sense in economic terms, but at least they feel confident that they will have something tangible (in this example, a new treatment plant) to show to their constituency.

In summary, therefore, the key, obvious, and generally overlooked message is that NRW must not be considered in a vacuum, but within the broader context of utility reform. The designer of any NRW program needs to look carefully at the *incentives for the managers and staff* of the program, as well as all the parties involved. Any program should ensure, as far as possible, that the incentives are properly aligned with the objective of developing an efficient and effective utility that meets the needs of its consumers.

It is for these reasons that performance-based service contracting, where performance improvement is made against defined contractual objectives, might offer an enabling environment and incentives conducive to reducing NRW, with immediate operational and financial benefits. It can therefore create a positive dynamic for reform, but should not be considered as a substitute for carrying out the broader institutional reforms necessary to promote the sustainability of the sector.

POTENTIAL FOR PRIVATE SECTOR INVOLVEMENT IN NRW REDUCTION ACTIVITIES

From the previous section, it can be seen that most utilities in the developing world lack the capacity to efficiently implement on their own an NRW reduction program. They operate under an inadequate incentive framework; they typically lack expertise, technology, and the practical experience of putting in place such programs; and they therefore need external assistance. An obvious source of assistance is the private sector, where involvement can take many forms, ranging from long-term PPP arrangements to service contracts or subcontracting of certain tasks. Depending on the option chosen, the private sector can bring the following:

- New technology and the know-how to utilize it efficiently
- Better incentives for project performance
- Creative solutions for the design and implementation of the program
- Qualified human resources
- Flexibility for field work (for example, night crews)
- Investment, under certain conditions

A number of options for involvement of the private sector in NRW reduction are presented below.

Delegated Management under a Public-Private Partnership (PPP) Contract

There are a number of established and well-studied PPP models for the delegated management of utilities, such as concessions, lease/affermage, and management contracts.[14] Long-term PPP contracts such as concessions are not designed solely for NRW reduction; however, the private operator typically has strong financial incentives to reduce the NRW level because this translates into higher revenues and lower operating costs, as well as the postponement of costly investments to increase production capacity. There are even cases of affermage contracts (like those in Senegal) where specific objectives for NRW reduction were included in the contracts, with bonuses or penalties for the private operator in case of compliance or noncompliance.

The situation is slightly different for management contracts, which are typically of shorter duration and targeted toward certain specific improvements. But even management contracts can be designed to address NRW reduction through the use of specific contractual targets and performance payments.

In all of these cases, the private operator can bring much-needed expertise and know-how, not only for the implementation of the NRW program but also for its design, as long as the contract provides sufficient flexibility. The private sector is fully responsible for identifying the most economical NRW activities and is accountable for the end results, among its other management responsibilities.

Evidence from a series of case studies[15] tends to confirm that a private operator can be very efficient in reducing NRW levels. However, large-scale delegated management PPP arrangements remain a controversial topic in many developing countries, and there is growing recognition that many water utilities in the developing world will remain under public management. There is therefore demand for contractual schemes involving the private sector, but without delegated management of the utility to the private sector.

Outsourcing of NRW Reduction Activities

At the opposite end of the spectrum, outsourcing of elements of NRW reduction activities is a widespread approach in public utilities of developed countries. Under this approach, a water utility subcontracts specific elements of an NRW reduction program to a private firm. This can range from a specific activity through to overall management of the NRW program. In all but the latter case, the utility remains in charge of the overall implementation of the program.

14. "Approaches to Private Participation in Water Services: A Toolkit," World Bank, PPIAF, 2006.

15. "Approaches to Private Participation in Water Services: A Toolkit," World Bank, PPIAF, 2006 (see appendix A: Examples).

This approach is particularly appropriate for all field work such as leak detection, pipe repairs, minor civil works, meter replacement and reading, updating the cadastre, and identification of illegal connections. There are several advantages for the utility in adopting such an outsourcing approach, including reduced unit costs through competitive bidding, more flexibility for night work, and mobilizing additional resources for dealing with backlogs. It also brings access to a specialized workforce and equipment.

Outsourcing of leak detection is nothing new. Many water utilities in Europe, the United States, and even in some developing countries use private leak detection contractors to survey the distribution network periodically. Unfortunately, this approach is limited in many developing countries by three major constraints:

- The lack of capacity of the water utility to implement a comprehensive program and to coordinate the work of various contractors.
- The often undeveloped nature of the local private sector. Depending on the country, simple labor-intensive tasks such as meter reading and pipe repairs can be subcontracted, but local firms with the capacity to conduct more technical tasks such as leak detection and network zoning are often not available.[16]
- Lack of knowledge about the existence of the various options and lack of guidance materials (for example, sample contracts, target setting, and payment mechanisms).

Technical Assistance Contracts

The traditional option for delivering NRW technical assistance in developing countries is one in which a public utility will contract a private company to design and/or provide implementation capacity building for an NRW reduction program. Such companies are typically consulting engineering firms or subsidiaries of private operators and construction companies engaged through the technical assistance/capacity building contracts. Often the water utility *believes* that it has delegated the entire NRW reduction program to the private partner, even though the contractor has to implement the project through existing utility staff who have no real incentives to deliver results and are unsure whether they should report to the contractor or to the utility management. In some cases also, the budget allocated for field works such as leak repair and equipment installation (such as meters and valves) was not sufficient, given the overall deterioration of the networks and the magnitude of the problems.

The fundamental weakness of this approach is that the private sector has limited control over the implementation program and thus cannot be accountable for the end result, but only for providing advice. The private contractor cannot, and does not, guarantee that at the end of the project the levels of NRW will have been reduced according to any specific target. Not surprisingly, therefore, there are countless examples in developing countries of NRW technical assistance/capacity-building contracts that have failed to reach their objectives.

Another frequent problem is that the NRW program is a small part of a larger development project; there is limited focus, and the NRW work often takes a lower priority compared with that of the physical investment program. The result is that everyone (the utility,

16. In the case of many PPPs, international private operators have played an active role in developing the capacity of the local private firms by subcontracting many activities as part of their drive to improve labor productivity.

the contractor, and the donor) enters into the assignment on a "best endeavors" basis, and the poor results are the inevitable consequence. In addition, the improvements made by the main project component (for example, construction of a new water treatment plant) can result in increased supply hours and improved pressure, which too often offset the achievements of the (insufficient) leakage reduction program.

A Different Approach: Performance-Based Service Contracting

Performance-based service contracting offers a potentially new approach to the NRW challenge. The concept is to contract a private firm to implement an NRW reduction program, as for the outsourcing approach described above, but with the difference that the private firm is not paid solely in exchange for services delivered, but paid also against meeting contractually enforced operational performance measures. It is in the spirit of the output-based aid (OBA) approach advocated by the World Bank,[17,18] which is based on the idea of paying the private sector for delivering results (that is, outputs), instead of for just a series of activities/inputs. In exchange for taking risks on project performance, the private contractor is given enough flexibility and resources to carry out the work according to its best judgment and experience. It effectively reduces the risk that the public utility will end up financing a large program with no or limited results by shifting the risks for meeting project objectives to the private contractor.

In practice, the applicability of performance-based service contracting to an NRW reduction program depends on the level of risk that the private sector is willing to take, which is itself linked to overall country risk, the specific conditions of the water utility, and the detailed contractual form.

Performance-based service contracting is a relatively new concept for the water sector in the developing world, but it is increasingly contemplated in other infrastructure and utility sectors as a way to improve efficiency and accountability of contracts with private providers. There are a few cases of large NRW reduction performance-based service contracts, but at this writing they have not been fully documented.

Their summaries and brief analyses are presented in section 4. Lessons learned from the case studies are presented in section 5, together with key issues to be considered when designing an effective performance-based NRW reduction service contracts.

PERFORMANCE-BASED SERVICE CONTRACTING FOR NRW REDUCTION: INTERNATIONAL CASE STUDIES

Performance-based NRW reduction is a relatively new concept. A limited number of large contracts have been let, but little information is publicly available. As part of this study, four water utilities involved in such contracts were visited:[19]

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17. Penelope Brook and Suzanne Smith, eds., Contracting for Public Services: Output-Based Aid and its Applications, Private Sector Advisory Services, World Bank, Washington, DC. http://rru.worldbank.org/Features/OBABook.aspx.

18. Philippe Marin, "Output-Based Aid (OBA): Possible Applications for the Design of Water Concessions," Private Sector Advisory Services, World Bank. http://rru.worldbank.org/Documents/PapersLinks/OBA%20Water%20Concessions%20PhM.pdf

19. All of these organizations were cooperative and provided valuable information on technical and contractual details, as well as the history of the projects. For confidentiality reasons, not all information received can be published, but the key contract and project details are described here.

- State of Selangor (Malaysia), where a large-scale contract for reducing physical and commercial losses has been in place since 1998 between the (at that time state-owned) water utility serving Kuala Lumpur and its surroundings, and a consortium led by a Malaysian company
- Bangkok (Thailand), where the Metropolitan Waterworks Authority (MWA) that supplies Bangkok outsourced physical loss reduction to private contractors from 2000 to 2004
- São Paulo (Brazil), where SABESP, the water utility that serves the São Paulo Metropolitan Region, experimented with different contractual approaches for reducing commercial losses with the private sector
- Dublin (Ireland), where the Water Division of the Dublin City Council contracted in 1997 an international private operator to implement a two-year contract for reducing physical losses

For each case study, the key project data are presented, along with a brief analysis of critical elements in the design of a performance-based water loss reduction contract:

- Scoping: What is the role of the private contractor? What are the NRW reduction targets?
- Incentives: How is the performance-based element of the contract structured?
- Flexibility: To what extent does the contract allow the private sector to be creative in the design and implementation of the NRW reduction activities?
- Performance indicators and measurement: How is NRW reduction measured?
- Procurement/selection: How was the private contractor selected?
- Sustainability: What happened after the performance-based service contract was completed? Does the contract include specific clauses to ensure transfer of know-how to the public utility?

Selangor State (Malaysia): The Largest NRW Reduction Contract

In 1997, the population of the Malaysian State of Selangor (and the Federal Territory of Kuala Lumpur) experienced a serious water crisis, caused by the El Niño weather phenomenon. This crisis situation provided the trigger for the government to start dealing with the high level of NRW that had affected the water utility for many years. An estimated 40 percent of the water produced was not invoiced, with leakage estimated at 25 percent, or around half a million cubic meters per day.[20] Halving the amount of physical losses would provide sufficient water to serve the equivalent of 1.5 million people and thereby avert the water shortage in Kuala Lumpur.

Faced with this crisis, the State Waterworks Department accepted a nonsolicited proposal from a consortium led by a local firm, in joint venture with an international operator. The contractor committed to reduce NRW by a specified amount agreed upon in advance, in a given time. The contractor had full responsibilities for designing and implementing the NRW reduction activities with its own staff, in exchange for an agreed-upon lump sum payment, with incentives for achieving the targets, including penalties for noncompliance of up to 5 percent of the total lump sum and a performance guarantee of 10 percent of contract value.

20. Approximately 800 liters per connection per day at around 30 meters average pressure.

The contractor was free to select the zones within the network on which to conduct NRW reduction activities. The lump sum was calculated to cover in advance all necessary activities, including leak detection and repairs, supply of equipment (pressure reduction), establishing NRW reduction zones (called "district metering areas" [DMAs]), identification of illegal connections, and customer meter replacement.

Given the innovative nature and size of the contract, a phased approach was agreed upon, starting with an 18-month pilot phase (Phase 1), whose objective was to test the validity of the concept on a limited portion of the network. The target for Phase 1 was to reduce NRW by 18,540 cubic meters per day (with subtargets for both physical loss reduction and meter accuracy improvement), in exchange for a lump sum payment equivalent to US$4.5 million, or US$243 per cubic meter per day of NRW saved.

Success of Phase 1 was essential to validate the concept and was therefore a precondition for the State Waterworks Department to enter into contract negotiations for Phase 2. The performance of Phase 1 actually exceeded the target, achieving savings of 20,898 cubic meters per day (approximately equally between commercial and physical losses). Twenty-nine DMAs (district metering areas, a core technical approach for physical loss reduction) were established with average savings of 400 cubic meters per day in each DMA, and around 15,000 meters were replaced. The cost to the State Waterworks Department was equivalent to US$215 per cubic meter per day.

Phase 2 of the Selangor NRW reduction contract follows a similar contractual framework, but extends over a nine-year duration. The overall target is to reduce NRW by 198,900 cubic meters per day, with a contract lump-sum price equivalent to US$105 million. This translates into an average cost of US$528 cubic meters per day, which is more than double the one observed in Phase 1, but covers not only the initial NRW reduction in Phase 2 but also the maintenance of reduced levels of NRW in all zones (Phases 1 and 2) until the end of the contract.

The contract began in April 2000, and interim results (beginning of contract year six) are available. A total of 222 NRW reduction zones have been established, spread around the entire distribution system, and more than 11,000 leaks were repaired (75 percent on service connections). Pressure-reducing valves were installed extensively. 119,000 meters (out of a total of 150,000 contractual minimum) have been replaced. The results in NRW reduction are so far impressive, with physical loss reduction of 117,000 cubic meters per day (already 20 percent above the year 2009 contract target of 97,500 cubic meters per day) and commercial loss reduction of 50,000 cubic meters per day.

Analysis of the Selangor NRW Reduction Contract

Phase 1 of the contract demonstrated that the concept works: a private firm can be contracted to efficiently reduce the NRW level to specific targets, provided that the contractor has flexibility to conduct the NRW activities and that there is a payment arrangement covering all necessary works and materials. One of the technical innovations was the universal use of pressure-reducing valves (even in very-low-pressure situations) to help regulate the operation of the network. Total savings achieved represented a quarter of the total losses at the beginning of the contract, or around 10 percent of water produced.

Scoping. Although Phase 1 was clearly focused on achieving NRW reduction over a relatively short period, the design of Phase 2 bundles NRW reduction activities together with the outsourcing of the management of both Phase 1 and Phase 2 portions of the network (the DMAs) over a long period. In Phase 2, therefore, as soon as a DMA is established, the contractor assumes full responsibility for the distribution system operation of this specific DMA for the entire contract duration—much longer than needed for the actual NRW reduction. This makes it difficult to assess the cost efficiency of the Phase 2 contract compared with that of the Phase 1 contract.

Incentives. The main incentive during Phase 1 was to be awarded Phase 2 of the project, so the contractor had obvious motivation to overachieve the targets. Such an incentive is missing in Phase 2, and a key problem is that the contractor therefore has no incentives to reduce NRW any further than the contractual targets (which have already been achieved four years before the end of the contract). It is very likely that the Phase 2 contractor could reduce NRW levels much further, and so the performance and cost efficiency of the contract could have been significantly increased if payments had been linked to actual loss reduction achieved, rather than having a fixed target and lump-sum payment.

Flexibility. The contractor enjoys a high degree of flexibility and can take all necessary actions to reduce NRW levels according to contract targets. This has been undoubtedly instrumental in reaching such impressive results, because the contractor could

- choose the parts of the network with a good potential for cost-effective physical loss reduction (high level of physical losses or high pressure or both) and
- analyze the entire customer meter database of the client and select the (minimum) 150,000 meters with the highest under registration (age, type, brand, size, and so forth). Selected meters did not have to be inside the DMAs.

The freedom of choosing zones anywhere in the network, as allowed under this contract, is far from ideal, because the zones chosen by the private contractor do not necessarily match the priorities of the utility. In practice, it leads to a dilution of the effort because newly improved portions of the network are scattered across the whole system, so that a significant proportion of the water savings are lost in the (yet unrepaired) neighboring areas.

- **Performance indicators and measurement.** Appropriate and simple performance indicators (savings in cubic meters per day for both physical and commercial loss reduction) have been used, and the measurement methodology and procedure are well described in the contract, including use of zoning and night-flow techniques.
- **Procurement/selection.** The contracts for both Phases 1 and 2 were negotiated without competition. Although this might have been justifiable for the first phase (at that time, a very innovative idea with high risk for the contractor), it is very likely that the cost of Phase 2 could have been substantially reduced if tendered competitively or even split into two or more packages.
- **Sustainability.** Sustainability of this project is not clear. Although the Phase 1 contract included training of the client's staff, this training had little effect, and the zones established during Phase 1 were soon handed back to the contractor again because the client was either not interested in, or not capable of, maintaining them. The experience

here highlights the need for any NRW strategy to address the issue of what to do once the PPP contract is finished.

Summarizing the lessons learned from the Selangor project, the pros and cons are the following:

+ Positive

- Demonstration that impressive results can be achieved
- Simple but appropriate performance indicator
- Clear performance-monitoring procedures

- Negative

- Negotiated contract, thus Phase 2 not cost-efficient
- No true performance contract because of use of fixed target
- Scattered zones for physical loss reduction, instead of focusing on one part of the distribution system

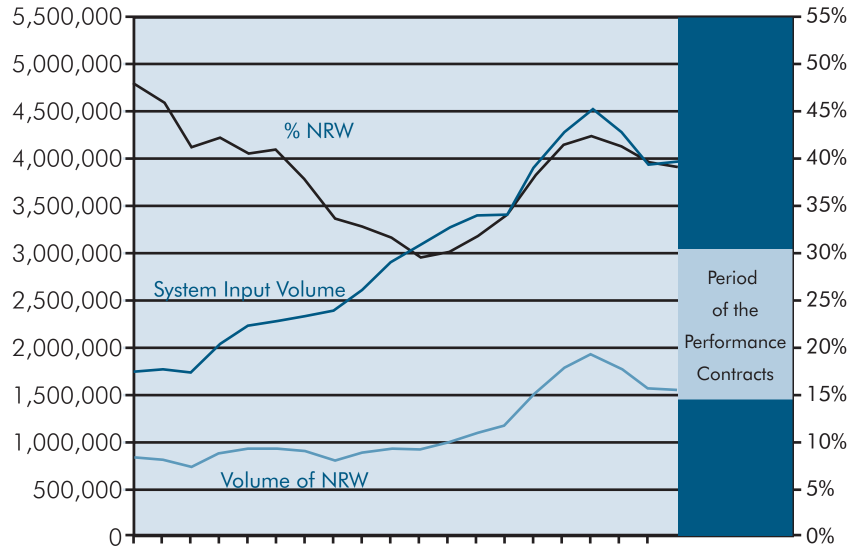
The real breakthrough of the Phase 1 contract was to demonstrate that it was possible to reduce physical losses drastically by contracting an experienced private firm and giving it flexibility to select and conduct NRW reduction activities with its own staff. The Phase 2 contract was less noteworthy, with a number of short comings, but it was significant in its size: the contractor was committing to an ambitious target of around 200,000 cubic meters per day NRW reduction, which had never been done before under a PPP arrangement.

Bangkok (Thailand): Performance-Based Service Contracts for Leakage Reduction

Water services in Bangkok are operated by a public utility, the Metropolitan Waterworks Authority (MWA). Like most water utilities operating in the megacities of Southeast Asia, MWA has been struggling for years to cope with demand from a fast-growing population. Major investments were made to increase production capacity (with production raised from 1.7 million to 3 million cubic meters per day between 1980 and 1990), and it seemed that NRW was also successfully reduced from 50 percent in 1980 to about 30 percent in 1990. However, this reduction in percentage terms was mainly the result of the substantial increase in production capacity, and despite significant efforts, the volume of NRW remained stable during this period at a high level of around 900,000 cubic meters per day.

During the 1990s, the improved supply situation caused by a massive increase of system input volume (from 3.0 million to 4.5 million cubic meters per day) led to a substantial increase in NRW, both in percentage and in volumetric terms, reaching its peak in 1997 (1.9 million cubic meters per day, or 42 percent), presumably caused by supply improvements and pressure increases. System input was then again reduced to below 4 million cubic meters per day, and NRW consequently decreased and stabilized, although at a high level of 1.5 million cubic meters per day in 1999. Since then, substantial efforts were undertaken and have resulted in NRW reduction by 200,000 cubic meters per day (to 1.3 million cubic meters per day, or 30 percent), although system input had increased to 4.2 million cubic meters per day.

Figure 2. MWA System Input and NRW data, 1981–2004



Source: Ken Kociba, compiled from MWA Annual Reports
m^3 = cubic meters

A significant part of this NRW reduction was to the result of the achievements of performance contracts, which the MWA decided to award to private contractors in 2000. The objectives of these contracts were to reduce physical losses in 3 of the 14 service branches of Bangkok (each one representing around 100,000 customers). The duration of the contracts was four years. They were competitively bid, but only two companies were prequalified and submitted proposals.

The basic design of these contracts was significantly different from that in the case of Selangor. There was no fixed target for leakage reduction, and payment was based in part on the actual water savings achieved through leakage reduction.[21] Although each contractor was free to carry out leakage reduction activities (such as detection, pipe repairs, main replacement, and installation of hydraulic equipment) as it saw fit, all this was done through the use of local firms, based on reimbursables. Instead of a lump-sum payment, the remuneration of the contractor comprised three elements: (a) a performance-based management fee (to cover overheads, profits, and foreign specialist staff), (b) a fixed fee (covering essentially the cost of local labor), and (c) reimbursables (for all outsourced services, works, and materials performed in the field—the biggest part of the project cost).

In terms of technical performance, the contracts can be considered a success. Physical losses in these three areas were reduced by 165,000 cubic meters per day. To give some

21. The calculation of the monthly savings is currently in dispute between the parties because alternative formulas are provided in two contract appendixes, and the difference between the two calculation methods is substantial.

Table 3 Characteristics of the Three MWA Water Loss Reduction Contracts

Contractor	**Contractor #1**		**Contractor #2**
MWA Branch	**Nonthaburi**	**Sukhumvit**	**Phasichareon**
Number of connections (conn.)	99,131	238,591	142,470
Initial pressure (avg.) [m]	5	8	8
Initial NRW [m3/day]	146,205	130,750	156,218
Initial NRW [l/conn./day]	1,475	548	1,096
Final NRW [m3/day]	106,300	97,353	64,313
NRW reduction [m3/day]	39,905	33,397	91,905
Final NRW [l/conn./day]	1072	408	451
DMAs established	86	76	73
Mains replacement [km]	130	156	265
% of mains replaced	5.2	4.0	18.0
Leak repairs	71,307	31,182	51,905
Leak survey [km]	15,158	8,933	21,649
Ratio of km leak survey to pipe length	6.1	2.3	14.7
Total contract costa [US$]	16.3 million	17.3 million	22.6 million
Cost per m3/day NRW reduction [US$]	408	518	246

Source: Authors, compiled from data provided by MWA
l = liters; m = meters; m3 = cubic meters; km = kilometers
a. The total contract costs are based on the MWA's understanding of how to calculate the management fee.

sense of perspective, the amount of water saved is equivalent to the volume needed to serve an additional half million inhabitants.

The total cost of these three contracts for MWA was US$56.2 million, which is equivalent to an average cost of US$340 per cubic meter per day saved. However, this figure is misleading, because one of the two contractors (Phasichareon branch) achieved more savings than the other two contracts combined, for a unit cost of only US$246 per cubic meter per day. This compares with US$408 and US$518 per cubic meter per day for the zones managed by the other contractor. The detailed technical data (Table 3) from each zone provides an interesting insight to explain the difference of performance between the two contractors. The more successful contractor (contractor #2 in Table 3) was significantly more active in conducting leakage surveys of the network and replaced 18 percent of the infrastructure, which translated into the most expensive contract of the three, but also the most efficient per unit cost of NRW saved. On the other side, the lower performance of the other contractor (contractor #1), especially for the Sukhumvit branch, suggests that too little leakage reduction activities did not lead to success. In addition, even though these two contracts had a cost less in total to MWA, the actual unit cost per cubic meter per day saved was much higher—suggesting that leakage reduction activities must be conducted intensively to be effective.

Analysis of the MWA NRW Reduction Contracts

It is interesting to compare the three Bangkok contracts with the Selangor contract:

- Improvement over Selangor: There were neither arbitrary targets nor lump-sum remunerations, but instead a true performance-based element, based on the actual volume of NRW saved. In addition, the fact that two different contractors were in place simultaneously allows for some useful benchmarking.
- Disadvantageous compared with Selangor: The high proportion of reimbursables, which transfers a substantial risk element from the private to the public partner. At least basic activities, such as leak detection, should have been included in the performance fee.

Scoping. The contract areas were clearly identified, as were the objectives of the contracts. The fact that the contracts did not stipulate targets allowed the most efficient contractor (Phasichareon branch) to conduct more intensive work, with much better performance and cost efficiency for MWA.

Incentives. The introduction of a flexible payment structure, without contractual targets, was clearly beneficial. The management fee was completely performance-based, and thus the contractor did have incentives to achieve good results. However, because the majority of the project costs (such as leak detection, leak repair, and pipe replacement) were reimbursable on a cost-plus basis, the contractor had little incentive to work in a cost-effective way. The discrepancy between the performance of the two contractors shows that incentive structure was not, in itself, a guarantee that they would behave efficiently.

Flexibility. As in the Selangor case, a high degree of flexibility was allowed; however, it is questionable whether major infrastructure investment decisions, such as selection of mains to be replaced and size of DMAs, should have been left entirely to the contractor.

Performance indicators and measurement. Savings were calculated based on the reduction of the percentage of unaccounted-for water, which was then related to volumes. Volume of water was then valued on the basis of the average tariff in the area. Savings were to be shared on a 50/50 basis. The concept was valid, but the contract documents unfortunately included two contradictory formulas that generated severe disagreement between the contract parties over how to calculate the management fee. Using simple volumes of water saved (as in Selangor) would have been a better alternative.

Procurement/selection. Contracts were tendered competitively, but competition was limited because only two firms were prequalified to bid for the three contracts.

Sustainability. It does not seem that the contractors put proper control and management systems in place that the MWA staff could then continue to use. However, MWA is aware of the problem and has recently tendered a project for advanced network monitoring, DMA establishment, and so forth.

Picture: courtesy of Roland Liemberger.

Summarizing the lessons learned from the Bangkok contracts, the pros and cons are the following:

+ Positive

- True performance-based service contracts, with a payment structure based on actual water saved
- Good results achieved (at least in two of the three contracts)

- Negative

- Too much freedom for making major infrastructure investment based on reimbursable payments, with little incentives for cost efficiency
- Major mistake in the drafting of the contract (formula for calculating performance, and thus payments)

São Paulo (Brazil); Commercial Loss Reduction and Bill Collection

Companhia de Saneamento Básico do Estado de São Paulo (SABESP), the utility that serves the São Paulo Metropolitan Region, is one of the largest public water utilities in the world (supplied population: 25 million). It has put in place a proactive approach to water loss reduction with the help of the local private sector. Leakage reduction is routinely carried out by a series of leak detection contractors that are paid per length of distribution network surveyed, and about 40 percent of the 26,000-kilometer network is surveyed every year.

However, commercial management, including identifying and replacing underregistering meters, as well as bill collection, had been traditionally left to in-house crews. In 2004, it was estimated that SABESP was losing revenues in the equivalent of a million cubic meters per day. Faced with this situation, SABESP decided to experiment with some innovative ways of utilizing the private sector under performance-based arrangements. These contracts are presented below: one of them dealt with the reduction of bad debts (which are not, strictly speaking, part of NRW, but have a similar negative impact on the utility's financial equilibrium), and the other was focusing on customer meter replacement.

Reduction of Bad Debts

The concept of the project was straightforward: contract local private firms to negotiate unpaid invoices and collect the agreed-upon amount, in selected service areas. The scope of the contracts was limited to domestic and commercial customers, with public institutions still being dealt with directly by SABESP. Several contracts were tendered, covering all of SABESP's branches. The initial contracts started in 1999 for a two-year duration. The contractors were remunerated by retaining a percentage of the debt collected. That percentage was bid by the contractors, and the winning bidder in each branch was the one that offered the lowest percentage figure.

The percentages of debt collected received by contractors varied among branches from 6 to 20 percent. The remuneration included a premium if collection was higher than 80 percent, increasing the total payment to between 8 and 25 percent of the debt collected. In addition, a bonus was paid to the contractor when the invoice was fully paid in cash by the customer. A termination clause allowed either party to terminate the contract in case the recovery ratio would be below 30 percent of the contractual bad debt amount.

The value of bad debt to be negotiated and partly recovered through the initial contracts (started 1999) was in about US$65 million. The concept behind these contracts was not original; subcontracting bill collection is common in many commercial activities, if not in water utilities. What was surprising was the result: a total of US$43 million, or 78 percent of this amount, was effectively collected by the contractors, which was well beyond SABESP's expectations. Even more of a surprise to SABESP was the extremely high proportion of cash collection: 70 percent of the US$43 million was paid in cash, compared with SABESP's normal experience that only around 7 percent of bad debt is paid in cash. The contractors' payment was substantial, at US$6.6 million, and SABESP expected that the good profitability of the contracts would increase interest among potential competitors and therefore lower bids in future tenders. Those contracts were in fact extended for another two years (until 2003), and in 2005 similar contracts were being put in place.

Increase of Large Customer Meter Accuracy

The São Paulo Metropolitan Region is the industrial heartland of Brazil, and industrial and large commercial customers and the many large condominium buildings account for a major portion of SABESP's revenues. In fact, 28 percent of total billed metered consumption and 34 percent of all revenues come from just 2 percent of SABESP customers. It was therefore strategic for SABESP to pay particular attention to the meters of these prime customers, and although this had always been done by its own staff, it was suspected that many large meters were significantly underregistering compared with their true levels of consumption.

SABESP came up with an innovative solution to this problem by tendering a series of turnkey contracts for meter replacement. The project target was to replace the meters of 27,000 large revenue accounts identified by SABESP. Five 36-month contracts were put in place, and each contractor was responsible for the analysis, engineering and design, supply, and installation of the new meters. There was no up-front payment, and the contractor had to prefinance the entire investment. The contractor was entitled to a payment based on the average increase in consumption volume, through a complex formula.

The concept of performance payments—rather than just paying for supply and installation—was chosen because resizing and flow profiling of the meters were the most critical activities in the contract. Given the high daily consumption of the large customers concerned, proper calibration could significantly increase metered flows and billing. By linking payments to the improved meter accuracy, SABESP ensured that the contractor would focus on these critical issues.

The results of the contract were remarkable. The total volume of metered consumption increased by some 45 million cubic meters over the contract's three-year duration, while revenues increased by Brazilian reais (R$) 172 million (US$72 million). Of this, R$42 million (US$18 million) was paid to the contractors, with a net benefit to SABESP three times as high, at R$130 million (US$54 million).

Analysis of the SABESP Contracts

The contract for debt collection, while in itself not original in design, achieved surprising results for SABESP, underlying the fact that public utilities can underestimate the potential for improving efficiency by contracting with the private sector.

The contract for large meter replacement was a truly innovative approach, quite similar to a build-operate-transfer (BOT) scheme. It also achieved remarkable results, but it is unclear whether this model would be replicable for other utilities, except for those with significant numbers of large customers and a high tariff for the top consumption categories.

Scoping. Both projects had limited but clearly identified scopes.

Incentives. Both projects provided strong incentives for the contractors to perform, while still allowing good profitability for the client. The meter replacement contract was not driven by financial needs (SABESP was perfectly capable of financing the purchase of these meters on its own), but the objective was to introduce incentives for optimizing the calibration of the new meters.

Flexibility. Compared with that in the contracts in Selangor and Bangkok, flexibility here was understandably limited because the scope and objectives of the projects were much narrower. Despite that, the contractors still had sufficient flexibility for the execution of the works.

Performance indicators and measurement. The contractors were reimbursed based on a percentage of the increased revenues. In the case of the meter replacement contract, a complex formula was introduced to properly account for the impact of the contractor's activities on metered volumes, as opposed to seasonal and other variations in consumption levels. This formula proved to work effectively.

Procurement/selection. Both contracts were competitively bid according to SABESP's strict procurement procedures.

Sustainability. The contracts for reduction of bad debt have now become standard practice for SABESP. The customer meter accuracy improvement project was a one-time removal of the backlog of meter replacements. It should now be easy for SABESP to maintain the accuracy of these meters on a regular basis.

Summarizing the lessons learned from the São Paulo contracts, the pros and cons are the following:

+ Positive

- Impressive results achieved
- Excellent examples for commercial loss-reduction contracts
- Appropriate performance indicators
- Clear performance-monitoring procedures

- Negative

- Nothing material

Dublin (Ireland)

Overview

In January 1994, the City of Dublin had to deal with a severe water shortage. This was caused by decades of underinvestment in the distribution network, combined with the absence of systematic active leakage control, which had allowed physical water losses to reach very high levels. Several areas of Dublin experienced intermittent water supply.

The first reaction was to ask for funds to build new treatment plants and expand existing ones. However, funding was not made available because of the high level of leakage.

A comprehensive study then identified, for the first time, the volume of water lost: every day, approximately 175 million liters of water, more than 40 percent of the existing treatment capacity, was estimated to be leaking away from the distribution network. The European Commission was approached, and the request for cofinancing of the planned "Dublin Region Water Conservation Project" was approved, with a focus on reducing physical water losses.

The project target was very ambitious: to reduce leakage over a two-year period from 40 to 20 percent (in volumetric terms, from 175,000 to 87,000 cubic meters per day). Given the aggressive nature of the reduction program, there was no alternative but to engage an experienced water-loss-reduction contractor to assist the City.

In November 1996, eight consortia were invited to submit bids. The contract was of limited duration—only two years—and focused on physical loss reduction. The contractor was responsible for establishing DMAs throughout the network, locating and repairing leaks, installing pressure-reducing valves, performing some network rehabilitation, and training of the Dublin water utility staff. The contract was designed essentially as a "target-cost contract," and the target was expressed in monetary terms (total cost of leakage and contract cost for the duration of the project)—taking the overall objective to reduce leakage to 20 percent into account. It included a bonus/penalties mechanism to provide some incentive for performance, based on a complex methodology combining actual project expenses with the marginal cost of physical losses.

The contract was won by a U.K. water utility, which was named the preferred bidder on a quality/cost basis. Significant details were left to be agreed upon during contract negotiations. The contractor's remuneration in the winning bid covered a management fee, technical labor, and all leak detection equipment. This did not include the cost of leak repairs, repair materials, and network rehabilitation, which were carried out through local subcontractors and covered separately as reimbursables under what were known as "compensation events" (see below).

The contractor established a total of 500 small DMAs (less than 1,000 connections each), covering the entire distribution network. Some 15,000 leaks were repaired, and about 20 kilometers of mains were replaced. Total leakage was reduced from 175,000 to about 125,000 cubic meters per day, and although the 20 percent leakage target was not achieved, the project was considered a success. The savings made were sufficient to end the water crisis. There was broad consensus that the original 20 percent target was not realistic, given the short duration of the contract.

The financial performance of the contract is less clear-cut. The extent of the work necessary to fix leaks was unknown to the client and to the bidders. The client therefore included in the contract what were known as "compensation events" (CEs) to cover the costs of leak repairs, network rehabilitation, and associated materials. These CEs were costs that the client knew would be expended, but their precise extent and location would not be known until the work began. The cost of the original scope of the target-cost contract, plus the CEs, were estimated by the client to total $30 million. The client agreed that these CEs would be added to the target cost as and when they were incurred by the contractor. For its part, the contractor would be reimbursed for these costs on a "cost-plus" basis, effectively transferring much of the risk to the client. The result was a contract that comprised (a) approximately $15 million as a competitively bid management fee, technical labor, and equipment component and (b) approximately $21 million as CEs to cover all of the costs of repairs and rehabilitation, reimbursed on a cost-plus basis. This final cost of $36 million can be compared with the original contract price of $30 million. The penalty for not reaching the 20 percent leak reduction target was calculated at only 2 percent of the contractor bid remuneration, though it represented a more significant portion of the contractor's profit element. When translated to unit cost, the cost of water saved for the Dublin water utility was estimated at $750 per cubic meter per day,[22] which, although high, is in line with the figures from Malaysia and Bangkok, taking the much higher cost of labor and civil works in Western Europe into account. In addition, the high unit cost of saving NRW in Dublin has to be offset against the higher value of that water saved.

Analysis of the Dublin NRW contract

Scoping. The full scope of the project, number of repairs, nature of repairs, and so forth could not be well defined during contract design because of a shortage of system and flow information. It was therefore agreed upon during the contract negotiations that the cost of repairs would be treated as CEs under the contract. The duration of the project was also too short for the ambitious target.

Incentives. In practice, treating the cost of repairs and rehabilitation as CEs diminished the rationale of the performance contract. This significant element of work and cost, which totaled almost two-thirds of the final contract amount and was reimbursed on a cost-plus basis, did not subject the contractor to the same incentives to perform as the core (management fee) part of the contract. The unrealistically high performance target, combined with a bonus/penalty mechanism that had only a marginal impact, was not an effective incentive. The reputational incentive, given the high visibility of this contract, clearly played a significant role in the final satisfactory performance.

22. Based on a euro/US$ exchange rate of 1:1 (second half of 1999).

Flexibility. The contractor enjoyed in practice a wide flexibility to carry out the leakage reduction activities, and this did allow it to achieve good technical results. The target-cost mechanism did provide an incentive for the contractor to work in a cost-effective manner in those areas subject to that mechanism. Although this incentive was not in place for the repair work, the client believes that this, in practice, did not prove to be a major problem in the operation of the contract. In particular, the client could exclude those costs not regarded as reasonable.

Performance indicators and measurement. The lack of customer metering was a major challenge, resulting in no reliable NRW baseline, and hence the contract relied on estimates based primarily on total water production. This was an added risk to the contractor, but which was significantly offset by the use of the contract's CE mechanism.

Procurement/selection. Although a competitive bidding process took place, the contract was largely a negotiated one because quality of the technical proposal was a major selection criterion and many clauses were left for negotiation.

Sustainability. Training and capacity building constituted one of the components of the contract and were taken seriously by both parties. Substantial transfer of technology took place in practice, and the Dublin water utility now undertakes active leakage control as a regular and important part of its day-to-day operations.

Summarizing the lessons learned from the Dublin project, the pros and cons are the following:

+ Positive

- The volume of physical loss reduction sufficient to end the water crisis and reestablish continuous supply throughout the system in only two years
- A robust system for active leakage control established and currently continued by the client

- Negative

- Missing baseline and an imprecise mechanism to calculate savings
- Weak penalty/bonus formula provided limited incentives
- Large cost elements reimbursed on a cost-plus basis
- Unrealistically high performance target

LESSONS LEARNED AND OVERALL CONCLUSIONS

In this chapter the key lessons learned from the study are summarized. At the end of the chapter the overall conclusions are presented on the opportunities to involve the private sector in reducing non-revenue water in water utilities in developing countries

The Actual Cost and Payback Period of NRW Reduction Activities

Most of the activities leading to the reduction of commercial losses, such as meter replacement or updating customers' cadastre, have a quick payback. They require limited investment and translate immediately into additional revenues for the water utility. The situation is more complex for physical leakage: the amount of investment required is more significant, and it involves (at least partly) investment in, and rehabilitation of, assets with very long lives.

Table 4: Unit Cost per Cubic Meter per Day NRW Reduction		
	Cost of NRW Reduction (in US$/m³/day)	
Bangkok	**Selangor**	**Dublin**
Contract 1 $400	Phase 1 $215	$750
Contract 2 $507	Phase 2 $500	
Contract 3 $240		

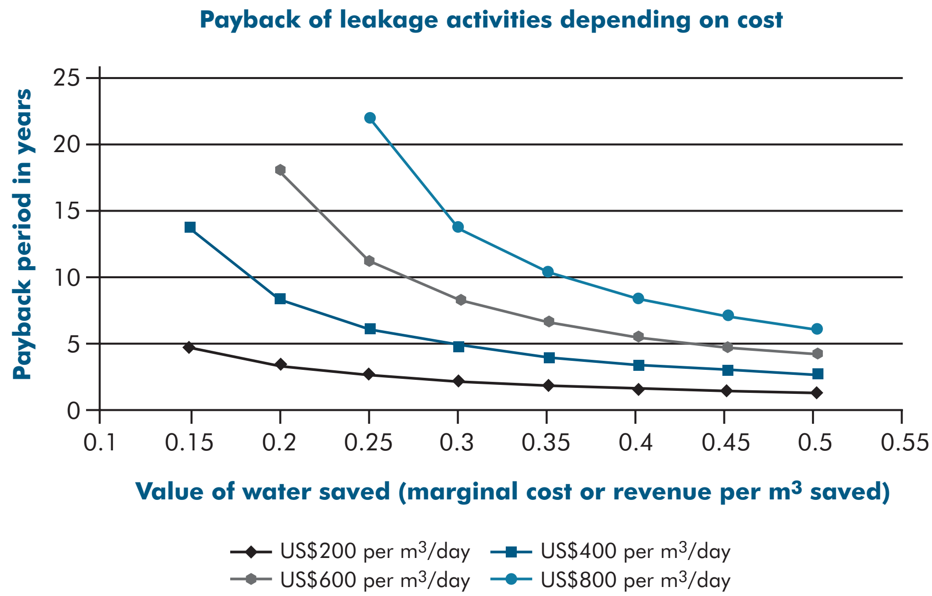
Source: Authors.
m^3 = cubic meters

There is very little information available in the literature on the actual unit cost of physical leakage reduction activities (that is, how much it costs to reduce leaks by one cubic meter of water on a daily basis). The case studies reviewed in this report provide a variety of unit costs for physical losses (table 4), ranging between US$215 in Selangor Phase 1 and US$750 in the Dublin contract for each cubic meter per day of water saved. Leaving aside the Dublin case, which comes from a developed country (with cost levels that are not comparable to the situation in developing countries, especially for labor), this suggests that the unit cost in developing countries of saving one cubic meter per day of water from physical leakage would be in the range of $215 to $500 per cubic meter per day. In a fairly well-designed, performance-based service contract, as was observed in the first phase of the Selangor contract and in the most efficient contract in Bangkok (the third one in the Phasichareon branch), a good estimate of the unit cost that can be obtained would be $250 per cubic meter per day.

These figures can be used to appreciate the economic benefit of leakage reduction activities. The payback for investment in leakage reduction activities depends directly on the unit cost of water saved per cubic meter per day and on the actual value of this water saved (marginal cost or revenue per cubic meter saved). Figure 3 presents the payback in number of years for leakage reduction activities, depending on the value of water, for a range of unit costs from US$200 to US$800 per cubic meter per day, and using a 10 percent discount rate. Within the range of unit costs considered, the actual payback of physical leakage reduction activities is between 2 and more than 30 years. This highlights the sensitivity of the payback of leakage reduction activities and the need to undertake a cost-benefit analysis as part of the preparation of any NRW reduction strategy. However, in the right circumstances, rapid paybacks are possible. For developing countries with high levels of losses (associated unit cost of leakage reduction in the region of about $250–$400 per cubic meter per day) and a relatively low value of water saved (around $0.20 per cubic meter), payback periods are approximately four to eight years, which makes leakage reduction an attractive investment.

In practice, the unit cost of water saved per cubic meter will increase as leakage reduction activities are carried out and the NRW level is reduced. The unit costs obtained in the case studies analyzed in this paper were obtained for utilities that started with high

Figure 3. Payback of Leakage Reduction Activities



Source: Authors.

levels of leakages, and it is possible that for better-performing utilities (that is, with low levels of NRW in the range of 15–20 percent) the unit cost of saving an additional cubic meter per day could be higher.

As already mentioned in section 2, the decision to implement a NRW reduction program must be based on a detailed cost-analysis based on the actual situation of the water utility. It is also essential for governments and financiers to keep in mind that, to be efficient, NRW programs directed at reducing physical leakages must include a sizable budget for investment and rehabilitation—a mistake often made under the more "traditional" technical assistance approach.

Using Performance-Based Service Contracts for NRW Reduction Can Be Very Effective

The case studies show that materially reducing physical losses with private sector performance contracts is a practical proposition. Despite the specific weaknesses of the contracts studied, they show that the job can be done, provided that the resources and incentives are put in place and that the private contractor has sufficient flexibility in the field. This compares sharply with more traditional approaches to reducing physical losses in developing countries, based on capacity building/technical assistance programs, which have shown few examples of achieving significant physical loss reduction.

The same applies to using the private sector for reducing commercial losses. Although the examples in this paper are limited to the case of São Paulo, it does suggest that outsourcing some activities to local private contractors through contracts with well-designed financial incentives can bring surprisingly positive results. Dealing with fraud is one notable area where recourse to outsourcing to the private sector deserves to be investigated further.

A key element of success, which is typically absent from the more traditional technical assistance approach, is that under a performance-based service contract, all of the loss reduction activities are transferred to, and carried out under the responsibility of, the private partner. This increases accountability and allows for a better integration and optimization of the various components of the NRW reduction program.

Performance-Based NRW Reduction: How Much Risk Can Be Taken by the Private Sector?

The concept of performance-based water loss reduction being relatively new, it is understandable that the examples so far come from projects that were very much contractor-driven, as innovative private sector companies started to "sell" the idea to water utilities. This approach was effective in ensuring that these projects actually happened and that the projects started after very short preparation times. The consequence is that contractual arrangements tended to be in favor of the contractor, not the public water utility. In fact, most of the contracts were target contracts (that is, payment to reach a specific performance threshold), rather than true performance contracts, and had modest penalties compared with the total contract values.

In reality, it is unlikely that a "pure" performance contract would be viable in most developing countries, given prevalent country risks, and in practice most contracts will contain a mix of fixed fees and performance payments. The key is then to strike the proper balance between fixed fee and performance payment, and in general the better the available information, the higher the performance component might be.

There is little doubt that for many utilities in developing countries, designing performance-based service contracts will be a challenge. Still, even introducing limited incentives for performance, through integrated contracts giving the private sector sufficient resources and flexibility to do the job, can deliver major improvements compared with the current, inefficient approach based on traditional technical assistance.

A Critical Issue: Choosing the Right Indicator for Leakage

Measuring leakage reduction in percentage of water produced is fraught with problems. Losses expressed in percentage of system input volume (as is common practice) are sensitive to variations in water production and consumption (including seasonal variations). This is especially relevant for the fast-growing cities in developing countries. It is therefore recommended that water utilities use indicators for contract performance calculated in volumetric terms and that the formulas for calculating such volumes be simple and objective—as was the case in Selangor. The Bangkok contract, on the other hand, used the percentage of NRW as the performance indicator, which could easily lead to wrong outcomes if demand increased or parallel actions were taken to reduce commercial losses. In fact, a complex set of formulas had to be devised into the Bangkok contracts (so complex that the parties could not apply them and eventually took the matter to court).

A related issue is the need for a reliable baseline. In a well-delineated network with DMAs and full metering, data on actual volumes become available, allowing for objective assessment of the performance of the contractor over time. However, in Dublin, water savings still had to be estimated because of the absence of customer metering. In such a situation, where no objective data are available and estimates must be relied upon for measuring performance, designing and implementing a performance-based scheme is more difficult. Where a water utility is suffering from intermittent service, there would be further challenges to developing a performance-based service contract.

Flexibility Is Essential for the Private Sector, but within Limits

One of the key reasons for the good technical performance of these contracts was the high flexibility enjoyed by the contractor to get the job done. Leakage reduction is a laborious job, requiring continuous efforts and numerous interventions in the network, which need to be conducted in a properly integrated manner to bring tangible results. This is particularly true for repairing pipes and rehabilitating deteriorated portions of the network. In the three cases of Selangor, Bangkok and Dublin, the private contractor had considerable leeway to carry out civil works as needed, under its own supervision, without having to refer to the contracting authority for approval. This does not mean, however, that a private contractor should be given complete freedom to act and spend money; therefore, contract flexibility should be matched with appropriate checks and balances.

In Selangor, the fact that the contractor was free to “cherry-pick” zones anywhere in the distribution system to conduct NRW activities probably undermined the benefits for the public utility. The contractor did not have to focus on the areas where the population needed urgent service improvement or where the water lost was more expensive for the utility (through high production costs). In fact, the scattering of the DMAs over the entire network resulted in a significant portion of the water saved being lost again in surrounding zones not dealt with by the contractor. It would have been better to require the contractor to concentrate all efforts in one supply area, where the achieved leakage reduction of 100,000 cubic meters per day would have made a real difference.

In Bangkok, it is open to debate whether the contractors should have been given total freedom to rehabilitate mains and decide on the size and design of DMAs, because these represent major infrastructure investments that have long-term impact on the operation of the network. The opposite is the case with the meter replacement contract in Sao Paulo, where the contract provided detailed technical specifications of the meters so that it was ensured that the contractor would use only meters of type and metrological class acceptable to SABESP. In Dublin, the lack of knowledge about the system during the contract design stage meant that significant flexibility was built into the contract through the use of the compensation events. These events were a major cost item for which the contractor was reimbursed on a cost-plus basis, thus providing much flexibility but with a more limited incentive than might be expected in a more performance-based approach.

Setting Targets: Incentives and the Need for Realism

The Selangor and Dublin cases illustrate the shortcomings of target-cost contracts with payment based on (often arbitrary) fixed performance targets. In Selangor, the contract still had three years to go at the time the case study was undertaken, but the contractual target had already been exceeded, leaving no incentives for the contractor to keep improving performance. This represents a significant loss of opportunity, given the know-how, setup, and resources that the contractor has in place. At the opposite end, the Dublin case was based on unachievable targets (particularly given the very short time frame of the contract), undermining the incentive framework. In fact, it appears that the so-called incentive formula was made such that even in case of nonperformance, the penalty for the contractor would be limited.

A related subject is whether potential performance payments should be capped. As a rule, indicative targets might be used in performance-based service contracts, but the incentive framework should be designed to allow the contractor not to be limited in case better-than-expected performance can be achieved. The exception would be for utilities with already low levels of losses and where there could be concern that the contractor might exceed the economical optimum (that is, when the cost of saving one extra cubic meter exceeds the actual value of the water). Given the high levels of NRW in developing countries, however, it is unlikely that a contractor would be able to reach this level within the scope of a first contract.

Apart from financial incentives, there might well be other ways in which a contractor can be incentivized. The case of Selangor, where good performance was achieved in the pilot phase, is a case in point: the desire to win the larger follow-up contract was an important factor in the contractor's superior performance. This might have also played a major role in the Dublin contract, whose visibility generated clear reputational incentives for the contractor.

Reimbursables: An Expensive Way to Get Things Done

NRW reduction programs, especially those focusing on physical loss reduction, necessarily involve a considerable amount of civil works, which is usually performed by local construction firms. One of the key advantages of the performance-based service contracts reviewed in this study was that significant budgets were included to finance network rehabilitation and investment. Although the private contractor should have flexibility for performing leak repairs, the use of subcontract arrangements on a reimbursement basis (for example, cost-plus) does not encourage the contractor to reduce quantities and get things done in the most cost-effective manner.

This is well illustrated in Dublin and in two of the Bangkok contracts, where the contractors had to use subcontractors for most of the work and could add overheads to any of them. A much better approach would be to include leak detection in the contractor's fee. Alternatively, leak repairs and other pipeline installation works could be paid through a classical schedule of rates that forms part of the contractor's bid. Large reimbursable components on a cost-plus basis should be avoided.

Sustainability: How to Ensure Sustainability after the Contract Period?

Outsourcing of NRW reduction activities can be done to either take corrective one-time action or introduce a permanent, sustainable system of outsourcing NRW management. Ensuring sustainability of the NRW reduction gains through appropriate transfer of know-how should be made an integral element in the design of performance-based NRW reduction service contracts.

Transfer of know-how seems to have been successful in Dublin, and the public utility has continued after the end of the contract with a sustained effort to maintain leakage at a satisfactory level. In Bangkok, there is little indication that the utility continued the activities with the same intensity after the contracts were completed.

The Selangor project, in turn, is an unfortunate example of what can happen if sustainability is not properly considered in project design. The contracts for both Phases 1 and 2 included substantial counterpart staff training (local and international; classroom and on-the-job). However, because the management of the public utility provided no incentives for its newly trained staff to take over ownership of the network zones repaired under Phase 1, the zones soon deteriorated, leakage levels rose, and the zones had to be handed back to the contractor (then working on Phase 2).

All of these contracts provided for significant capacity building of the public utility staff; yet it is unclear why there are such differences in project sustainability. It is likely that management commitment and the overall corporate framework of each utility played a major role.

In a well-designed NRW reduction strategy, the continued use of the private sector should be a matter of choice for the public utility, rather than a necessity. If the private sector is to continue as a provider of NRW management services, then lessons learned from initial PPP contracting arrangements should be included in subsequent contracts. The incentives and skill sets required for a "maintain low levels of NRW contract" will be different from those of a "reduce NRW contract," and further work will be required on this issue once the use of the private sector in NRW management becomes more established.

The Problem of Intermittent Supplies

Quantifying existing levels of NRW under conditions of intermittent supplies is difficult. This was not a challenge faced in any of the case studies, but is one that is faced in many developing-country utilities. This study has not been able to address this specific issue, but clearly it raises significant design challenges for a performance-based service contract. Reducing supply hours would lead to a proportional reduction of leakage, but that does not mean that a contractor should be allowed to do that. On the other hand, the public utility might be able to extend supply time by increasing the water entering the system, but this would likely result in an increase in leakage resulting from longer leak run times and higher pressures, potentially penalizing the contractor and resulting in increased operating costs for the utility. In these cases, the allocation of responsibilities in the contract and the flexibility given thereby to both parties must be the result of a thorough assessment of the particular situation of each water utility.

A Necessity for Success: Good Contract Preparation

Finally, and obviously, good contract preparation and baseline setting are essential to provide a sound basis for successful project implementation. The case studies show various levels of quality in contract preparation and baseline setting and—as a consequence—in project effectiveness. Baseline setting is particularly important because it determines the feasibility of measuring objectively the contractual performance of the private sector, which is a prerequisite for introducing financial incentives for results.

The SABESP contracts were well prepared, based on a wealth of information and with a clear idea of what could be achieved. Phase 1 of the Selangor contracts was also well designed for a pilot contract, but it was then scaled up to a US$100 million Phase 2 project without taking the opportunity of learning from the Phase 1 result and thus not improving the efficiency of the concept.

On the opposite end of the spectrum, the Dublin project seems to have been designed under the pressure of emergency. It had neither a realistic target (too high for such a short time frame) nor a reliable baseline. Although it succeeded finally in solving the water shortages in the city and introduced a long-term active leakage control program (that continues to be implemented), the costs of so doing were mainly derived on a cost-plus basis, with relatively low financial incentives to the winning bidder.

CONCLUSIONS

This paper was prepared as part of a Public-Private Infrastructure Advisory Facility (PPIAF)–financed study to investigate opportunities for the use of the private sector to assist water utilities in developing countries in reducing non-revenue water. During the course of the study, the scale of the challenge and the associated opportunities became clear. The fact that in developing countries alone more than $2.9 billion of additional cash could be generated from reduced costs or increased revenues associated with a realistic 50 percent reduction of physical and commercial losses should capture the attention of donors and developing countries' governments alike. Achievable reductions in physical losses should release at least 8 billion cubic meters per year of already-treated water—enough to service an additional 90 million people without drawing further on scarce water resources. In practice, good paybacks are possible with well-designed NRW reduction programs; therefore, if nothing else, NRW reduction makes business sense, although each opportunity has to be assessed in terms of its particular cost-benefit ratio.

The case to reduce levels of NRW is in fact so compelling that any sensible person would wonder why this problem has not already been addressed. Within the sector, there have of course been many attempts to tackle this issue. NRW reduction is a common element of past projects funded by multi- and bilateral organizations, but they have often not delivered the desired result because reducing NRW goes to the heart of many of the failings of developing-country water utilities and to the lacks of good governance and an enabling environment for efficient service delivery to the population. These include (among other things) (a) the often significant opportunities for staff and managers to achieve personal gain through fraudulent practices (illegal connections and corrupt meter readings), (b) politicians and utility managers who (for many reasons) would rather cut a tape opening a new treatment plant than dig up roads to provide more water for customers, and (c) lack of flexibility of public sector personnel systems that limit the possibility of introducing the key ingredient of successful NRW reductions: that of performance-based incentive schemes for managers and staff.

So, can the private sector help ailing public sector utilities in developing countries reduce NRW? This study indicates that the answer can often be "yes," even though the performance-based service contracting approach described should not be seen as a substitute for overall sector reform. They can provide an efficient means to achieve significant improvements in operational and financial efficiency, thereby creating immediate benefits and fostering a positive dynamic to support further reform. It is based on a win/win solution for both the public and private sectors:

- The public sector has limited capability and little interest to carry out the NRW reduction work itself.
- The private sector has the skills and the incentive to carry out such work.

What the study also shows is that NRW reduction can be achieved through contractual schemes that allow a water utility to remain under public management. In that regard, performance-based service contracting has considerable potential in situations where introducing the private sector through deeper forms of PPP (such as a concession, lease, or management contract) is not considered a viable option politically. To be successful, however, the study shows that good preparatory work is required. The starting point is to develop a strategy based on a sound baseline assessment of the sources and magnitudes of the NRW. Such a strategy needs to consider both the short and long terms (for example, the achievement of short-term reductions versus how to maintain lower levels of NRW over the long term). It is during strategy development that opportunities for teaming with the private sector can be identified.

The design of a performance-based service contract needs careful attention, as noted in the report. Key is the creation of an incentive framework that encourages the private sector to deliver reductions in the most cost-effective manner and allocates risk appropriately between the parties. Many of the case studies illustrate that target-cost contracts were being used, rather than true performance-based service contracts. In such cases, inappropriate targets can constrain the delivery of reduced NRW (the target has been achieved, so why do any more reductions?) in a way that a performance-based service contract would not (the more reduction, the greater the payment).

It is not necessary to repeat all of the lessons learned and summarized in the previous section, but sufficient flexibility, choice of appropriate and realistic targets, and limiting cost-pass-through items are obviously critical issues. The authors hope that sufficient experience and information are presented in this document to encourage public sector utilities to explore the possibility of using the private sector to reduce NRW through performance-based contracting. The case studies, while limited in number, provide examples of both good ideas and those to be avoided—but hopefully enough to help a utility and its consultants devise better cost-effective contractual arrangements suited to their conditions.

APPENDIX 1. NON-REVENUE WATER: THE TECHNICAL ISSUES

Assessing the Source and Amounts of NRW

Over the past decade, considerable work has been undertaken to develop a reliable set of tools and an internationally applicable methodology that allow water losses to be evaluated and managed in a scientific manner.

Preparing a baseline to establish current levels of water losses (by carrying out a water audit that leads to a water balance) is the first step for any utility wanting to reduce water losses. NRW reduction activities can then be planned using the baseline.

Creating a baseline is therefore a first—and critical—step. Strangely enough, it is a step often overlooked in the development of many urban water supply projects. A standard template[23] and terminology for categorizing and quantifying NRW, based on the initial version of the International Water Association (IWA),[24] is shown in Figure 4.

The situation is exacerbated by the obvious problem for managers of water utilities in the developing world: deficient water production and customer metering and limited knowledge of their distribution network hydraulics means that physical loss management, if carried out at all, is based more on a process of "guesstimation" than on an objective analysis and the application of proven technical solutions. Several basic issues are often overlooked:

- Most physical losses are caused by small leaks that are "invisible" (that is, they don't come to the surface). A visible mains burst may cause a one-time water loss of several hundred cubic meters of water in a short period of time, but because it is visible, it will be quickly repaired. On the other hand, a small leak from a service connection (for example, leaking at a rate of, say, only 1 cubic meter per hour) that does not appear on the surface will continue to lose nearly 9,000 cubic meters of water each year—unless it is eventually detected.
- Network pressure has a direct, approximately linear, relationship with physical losses (for example, 10 percent more pressure translates into about 10 percent more leakage in volume). Leak detection based only on pipe repairs often leads to increased pressures in other parts of the system, stimulating more leakage, much to the dismay of the utility managers. Pressure *management* (not necessarily reduction!) is of utmost importance, especially in low-pressure systems[25] with poor infrastructure condition.

In the past decade, a comprehensive set of analytical tools, water-loss-reduction strategies, and specialized equipment has been developed, but many water utilities are not aware of these. As a result, the gap between well-managed NRW reduction programs and the situation in most of the world's water utilities is widening at a fast pace. In

23. This standard water balance template has been developed for the training materials of the World Bank Institute.

24. Similar water balance templates have become (or are becoming) national reporting standards in a growing number of countries (for example, Australia, Canada, Germany, New Zealand, and South Africa) and in the United States in selected states (for example, Texas and California), and they are promoted by the American Water Works Association (AWWA) Water Loss Control Committee.

25. J. Thornton, M. Shaw, M. Aguiar, and R. Liemberger, "How Low Can You Go? A Practical Approach to Pressure Control in Low Pressure Systems," Conference Proceedings, IWA Leakage 2005 Conference in Halifax, Nova Scotia, Canada. (download from http://waterloss2007.com/Leakage2005.com/index.php)

Figure 4. International Water Balance

<table>
<tr><td rowspan="9">System Input Volume</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="7">Non-Revenue Water</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Commercial Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Metering Inaccuracies and Data Handlikng Errors</td></tr>
<tr><td rowspan="3">Physical Losses</td><td>Leakage on Transmission and/or Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to Point of Customer Metering</td></tr>
</table>

Sources: IWA and World Bank Institute.

developing countries, this is often compounded by a feeling of powerlessness (for example, that the network is so deteriorated that nothing can realistically be done about it and that there is no hope to move from intermittent supply of water to continuous service).

Water Loss Performance Indicators

To allow for inter utility comparison and to measure changes in NRW performance over time, it is important to have standardized performance indicators, calculated according to a clearly defined methodology and using standard definitions.

The most widely used performance indicator for water loss performance is the percentage of NRW as calculated by dividing total volume of NRW by the total system input. Although an obviously important figure, many practitioners tend to overlook its shortcomings for properly assessing water losses:

- It does not indicate the ratio between physical and commercial losses.
- It is dependent on utility-specific distribution network characteristics (for example, network length and number of connections).
- It is highly dependent on supply time (intermittent supply) and average operating pressure (two parameters for which wide variations are observed in developing countries).
- It is obviously highly dependent on the level of consumption.

NRW expressed as a percentage of system input volume is therefore not very useful when comparing the water loss performance between utilities. (In Table 6, exemplary systems are presented to illustrate the problem.) The lesson is that for a proper understanding of the water loss situation of a utility, and for the design of a loss reduction strategy, it is important to produce a water balance so that the ratio between physical and commercial losses is known and then to use appropriate indicators for physical and commercial losses.

Pictures: Courtesy of Roland Liemberger and Ronnie McKenzie.

Commercial losses are best expressed as a percentage of the authorized consumption. In well-managed utilities with a good customer meter replacement policy, commercial losses should be only a few percentage points of authorized consumption. It is important not to express commercial losses as a percentage of the total system input volume because this could be very misleading in systems with high leakage.

Physical losses must always be related to the distribution network. The following physical loss performance indicators are commonly used:

- Physical losses in cubic meters per kilometer of main per day (most of Continental Europe)
- Physical losses in liters per service connection per day

Because the majority of all leaks occur on service connections (including the connecting point to the main pipe), physical losses in liters per service connection per day is the better performance indictor.[26]

In intermittent supply situations, the average daily supply time has to be taken into account when calculating the indicator.[27]

The only problem with this indicator is that it does not take operating pressure into account. It is therefore important to always also state the average pressure when comparing with other utilities.

Deciding what level of losses is "acceptable" is not a simple task, because it depends on the specific conditions of each utility, both operational (network length, connection density, service pressure) and commercial. Economically, the target should be derived from a financial/economic analysis that determines the optimal level of leakage in any situation (that is, when the marginal cost of saving a cubic meter of water equals the marginal cost of supplying it).

26. With the exception of transmission pipelines or rural water supply systems with a connection density of less than 20 connections per kilometer of main pipeline.

27. 200 liters per connection per day in a system with only 12 hours of supply time would mean 400 liters per connection per day in a continuous supply situation. Consequently, 400 liters per connection per day has to be used as a performance indicator.

As a rule of thumb, and based on extensive experience, a simple matrix was published in 2005[28] that provides some insights into typical values for different situations. This approach can be used to classify the leakage levels for utilities in developed and developing countries into four categories:

- **Category A:** Further loss reduction may be uneconomic unless there are shortages; careful analysis needed to identify cost-effective improvement
- **Category B:** Potential for marked improvements; consider pressure management; better active leakage control practices, and better network maintenance
- **Category C:** Poor leakage record; tolerable only if water is plentiful and cheap; even then, analyze level and nature of leakage and intensify leakage reduction efforts
- **Category D:** Highly inefficient; leakage reduction programs imperative and high-priority

Why is there such a rather "artificial" split between "developed" and "developing" countries introduced? The reason is that the current gap in performance is such that setting targets for developing countries based on the performance of the best utilities in the developed world could easily be counterproductive. When setting goals, one must be realistic and take into consideration the difficult environment in which water utilities in the developing world are operating.

Table 5 provides a physical loss assessment matrix.

- **System A** is an example from a developed country with "only" 13 percent NRW. Use of this percentage indicator alone would give the impression that losses were not excessive. However, in reality, physical losses of 333 liters per connection per day (at 50 meters pressure) are fairly high by international standards, and the use of the "loss per connection per day" indicator would highlight that further NRW reductions were possible. This particular system has a large proportion of condominium buildings, and so the number of connections relative to the population is low. Physical losses could easily be reduced by, say, 200 liters per connection per day, generating overall savings in the order of 30,000 cubic meters per day. Assuming marginal (production) cost of water of US$ $0.30 per cubic meter, this is equivalent to yearly savings of more than US$3 million.
- **System B** is an example with very low per capita consumption and a much higher number of connections in relation to the supplied population. Although 29 percent NRW sounds rather high, the physical loss level (143 liters per connection per day at 30 meters pressure) is excellent for a developing country.
- **System C** with only 16 percent NRW has a much higher physical loss level (240 liters per connection per day at only 20 meters) than System B.
- **System D** has intermittent supply (12 hours per day) and therefore a relatively modest level of NRW (20 percent). But if the physical loss indicator is calculated properly (taking

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28. R Liemberger and R. McKenzie, "Accuracy Limitations of the ILI: Is It an Appropriate Indicator for Developing Countries?" Conference Proceedings, IWA Leakage 2005 Conference in Halifax, Nova Scotia, Canada. (download from http://water-loss2007.com/Leakage2005.com/index.php)

29. The cases are illustrative only to make the reader think about the issue. They were constructed based on the author's experience and are realistic, even if they are not based on any particular system. (In a possible future update of this paper, it would be interesting to substitute real cases for this table.)

Table 5: Physical Loss Assessment Matrix

Technical performance category	ILI[a]	Liters/connection/day when the system is pressurized at an average pressure of: 10 m	20 m	30 m	40 m	50 m
Developed countries						
A	1–2		< 50	< 75	< 100	< 125
B	2–4		50–100	75–150	100–200	125–250
C	4–8		100–200	150–300	200–400	250–500
D	> 8		> 200	> 300	> 400	> 500
Developing countries						
A	1–4	< 50	< 100	< 150	< 200	< 250
B	4–8	50–100	100–200	150–300	200–400	250–500
C	8–16	100–200	200–400	300–600	400–800	500–1,000
D	> 16	> 200	> 400	> 600	> 800	> 1,000

Source: Roland Liemberger.
m = meters
a. The Infrastructure Leakage Index (ILI), a leakage benchmarking indicator developed by the IWA, is the ratio between the present volume of physical losses to the minimum achievable volume at the present pressure. (It was used to develop this table, but is not discussed in this report.)

supply time into account), it can be seen that physical losses are very high (300 liters per connection per day [when the system is pressurized] at only 15 meters pressure).[30]

- **System E:** In this scenario, it is assumed that System D is now supplied continuously. Although not one leak has been repaired and the pressure remains unchanged, the volume of physical losses doubles, and NRW increases to 29 percent. But by looking at the physical loss performance indicator (liters per connection per day [when the system is pressurized]), it can be seen that the level of leakage has not changed. This is a typical example of what happens when production capacity is increased and, despite a (maybe even successful) NRW reduction program, NRW (expressed in percentage points) increases.
- **System F:** is an example of a village with a population of only 25,000 people and low per capita consumption. NRW (37 percent) seems to be very high, but in reality the leakage performance is good (192 liters per connection per day at 40 meters pressure).[31]

These examples illustrate that expressing NRW as a percentage of system input volume can be very misleading because of often very big differences in levels of consumption, network characteristics (connection density), operating pressure, and (last, but not least) supply time.

30. This is a common problem in India, where most water supply systems are operated on an intermittent basis.

31. Small systems with a high NRW percentage are often judged wrongly and might have a fairly good leakage performance.

Table 6: Water Loss Performance Indicators of Six Example Systems

		System A	System B	System C	System D	System E	System F
		Developed Country	Developing Country	Developing Country	Developing Country	Developing Country	Developing Country
Population		2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	25,000
Service connections	number	150,000	400,000	250,000	300,000	300,000	6,000
Average pressure	m	**50**	**30**	**20**	**15**	**15**	**40**
System input volume	m^3/day	**460,000**	**255,000**	**490,000**	**375,000**	**420,000**	**3,500**
Per capita consumption	l/c/d	150	80	130	100	100	80
Domestic consumption	m^3/day	300,000	160,000	260,000	200,000	200,000	2,000
Commercial consumption	m^3/day	100,000	20,000	150,000	100,000	100,000	200
Commercial losses	m^3/day	10,000	18,000	20,000	30,000	30,000	150
Physical losses	m^3/day	50,000	57,000	60,000	45,000	90,000	1,150
Total NRW	m^3/day	**60,000**	**75,000**	**80,000**	**75,000**	**120,000**	**1,300**
NRW	% of system input volume	13	29	16	20	29	37
First impression of NRW level		LOW	HIGH	LOW	MEDIUM	HIGH	HIGH
Daily supply time	hours	24	24	24	**12**	24	24
Commercial losses	% of authorized consumption	3	10	5	10	10	7
Commercial loss level		LOW	MEDIUM	LOW	MEDIUM	MEDIUM	LOW
Physical losses	l/conn./day (when the system is pressurized)	333	143	240	300	300	192
Physical losses Performance category		C	A	C	D	D	A
Physical loss level		Relatively HIGH	LOW	Relatively HIGH	Very HIGH	Very HIGH	LOW

Source: Authors

l =liters; m = meters; m^3 = cubic meters; km = kilometers

Although NRW percentage is widely used, especially in the political dialogue, it has to be understood that it is not an appropriate indicator for investment decisions, utility performance assessment, and (especially international[32]) benchmarking.

Developing an NRW Reduction Strategy

The first, basic step to developing a strategy for management of NRW is to gain a better understanding of the amount and sources of NRW (calculating the water balance) and the factors that influence its components. These are the typical questions[33] to be considered:

- **How much** water is being lost?
- **Where** is it being lost from?
- **Why** is it being lost?
- **What strategies** can be introduced to **reduce** losses and **improve** performance?
- **How** can the strategy be **maintained** and the achievements **sustained**?

This diagnostic approach, followed by the implementation of solutions that are practicable and achievable, can be applied to any water company to develop a strategy for NRW management. This approach will also provide a systematic basis for developing and monitoring any performance-based NRW reduction arrangement.

In practice, a tailor-made NRW reduction strategy might address only physical losses or only commercial losses, but in most cases it will be required to deal with both. A wide array of activities must typically be carried out.

It is often thought that dealing with physical losses mainly involves pipe repairs, but in reality a sustainable **physical loss control strategy** must comprise four main elements:

- **Active leakage control:** monitoring network flows on a regular basis to identify the occurrence of new leaks earlier so that they can be detected and repaired as soon as possible
- **Pipeline and asset management:** managing network rehabilitation in an economical manner to reduce the need for corrective maintenance
- **Speed and quality of repairs:** repairing leaks in a timely and efficient manner (often requiring a thorough shakeup of working practices, organization, and stock keeping of repair materials)
- **Pressure management:** regulating network pressure through the judicious use of pressure-reducing valves (often an underestimated option for leakage reduction)

The design of a **commercial loss reduction strategy** will very much depend on local circumstances, but is likely to comprise:

- **Improving customer meter accuracy.** Ensuring that customer meters are in proper working condition and duly replaced at the end of their useful lives reduces under-metering and recourse to estimated billing.

32. The weakness of NRW percentage as an indicator becomes obvious if systems with intermittent supply are compared with continuously supplied systems, low-pressure systems with high-pressure systems, and large cities with small towns.

33. M. Farley and S. Trow, Losses in Water Distribution Networks, IWA Publishing (2003), ISBN 1900222116.

- **Improving meter reading and billing.** A significant portion of commercial losses comes from mistakes in the meter reading and billing chains, not only because of poor technology, antiquated cadastres, and data-handling errors in the office but also because of fraudulent practices on the part of utility staff.
- **Detection of illegal connections and water pilferage.** Contrary to common belief, a large portion of water stolen from public utilities does not come from poor, marginal urban areas, but rather from large industrial customers and those with political clout and enough resources to bribe utility staff and management. Allowing illegal connections and such fraudulent behavior is unfair for those in the population who do pay their bills, especially the poor, and works against promoting a culture of good governance.

An important point to mention is that a precondition for *any* NRW reduction strategy is to provide incentives for management and staff of the water utility to deliver on, and maintain, the reduction achieved. This has been the missing feature of most attempts to reduce NRW and is one of the main reasons why utilities, particularly in developing countries, have been unable to improve their performance.

Cost-Effectiveness of NRW Reduction

When developing an NRW reduction strategy, it is important to understand that costs differ substantially, depending on the activity being undertaken. A brief cost-benefit assessment of the various activities and strategies therefore has to be prepared, made on the basis of a reliable water balance.

Reducing **commercial losses** is nearly always cost-effective and offers fast payback. The activities are technically easy to carry out, but politically difficult, because it often requires taking a strong stance against fraudulent practices of utility staff and the (small) portion of the population benefiting from the status quo.

On the other side, reduction of **physical losses** through leakage control can be expensive, requires significant technical know-how, and must be carried out extensively to bring results. Water companies must seek to achieve an economic balance between the costs of leakage control and the benefits that accrue (see bibliography[34,35] for methodology for estimating an economic level of leakage).

34. D. Pearson and S. Trow, "Calculating Economic Levels of Leakage," Conference Proceedings, IWA Leakage 2005 Conference in Halifax, Nova Scotia, Canada. (download from http://waterloss2007.com/Leakage2005.com/index.php)

35. "Leakage Control Policy and Practice," Doe/NWC, reprinted by WAA/WRc, Report 26 (1980, 1985).

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