

# Performance based Non-Revenue Water Reduction Contracts

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## Introduction

One of the major challenges facing water utilities in the developing world is the high level of water losses either through physical losses (leakage) or theft of water from the system, or from water users not being properly billed. This difference between the amount of water put into the distribution system and the amount of water billed to consumers is known as “non-revenue water” (NRW).

The total cost to water utilities caused by NRW worldwide can be conservatively estimated at \$15 billion/year. More than a third of that occurs in the developing world, where about 45 millions m<sup>3</sup> are lost daily through water leakage in the distribution networks—enough to serve nearly two hundred million people. Similarly, close to 30 millions m<sup>3</sup> are delivered every day to customers but are not invoiced because of factors like pilferage, employees’ corruption, and poor metering. These challenges

seriously affect the financial viability of water utilities through lost revenues, lost water resources, and increased operational cost, thus reducing their capacity to fund necessary expansions of service, especially for the poor.

A high NRW level normally indicates a poorly run water utility that lacks the governance, autonomy, accountability, and the technical and managerial skills necessary to provide reliable service. The private sector, through well-managed performance-based service contracting, can help water utilities with the technical and managerial skills to carry an effective NRW reduction programs.

### Box 1: The three components of non-revenue water:

**Physical (real) losses** consist of leakage from the system and overflows at the utility’s storage tanks. They are caused by poor operations and maintenance, inadequate leakage control, and poor quality of underground assets.

**Commercial (apparent) losses** are caused by customer meter under-registration and data handling errors, as well as thefts of water in various forms.

**Unbilled authorised consumption** includes water used by the utility for operational purposes, water used for fire fighting, and water provided free to certain consumer groups.

## The case for reducing NRW

**Table 2:** Estimates of worldwide NRW volumes (billions of cubic metres/year)

	Supplied population, millions (2002)	System Input l/capita/day	ESTIMATES OF NRW					
			NRW as share of system input (%)	Ratio (%)		Volume, billion m <sup>3</sup> /year		
				Physical losses	Commercial losses	Physical losses	Commercial losses	Total NRW
<b>Developed countries</b>	744.8	300	15	80	20	9.8	2.4	12.2
<b>Eurasia (CIS)</b>	178.0	500	30	70	30	6.8	2.9	9.7
<b>Developing countries</b>	837.2 <sup>2</sup>	250	35	60	40	16.1	10.6	26.7
<b>TOTAL</b>						<b>32.7</b>	<b>15.9</b>	<b>48.6</b>

Source: World Health Organisation, IB-Net, and authors' estimates.

Research by international institutions is helping us understand the true magnitude of the losses from NRW, since utilities responsible for the losses have proven either unwilling or unable to provide such information. The World Bank database on water utility performance, known as IB-Net ([www.ib-net.org](http://www.ib-net.org)), includes data from more than 900 utilities in 44 developing countries. The average figure for NRW level in developing countries utilities covered by IB-Net is around 35 percent (table 1) - representing a value of \$5.8 billion (table 2).

**Table 3:** Estimated value of NRW and its components

	Marginal cost of water (US\$/m <sup>3</sup> )	Average tariff (US\$/m <sup>3</sup> )	Cost of physical losses	Lost revenue due to commercial losses	Total cost of NRW
			Estimated value (US\$ billions/year)		
<b>Developed countries</b>	0.30	1.00	2.9	2.4	5.3
<b>Eurasia (CIS)</b>	0.30	0.50	2.0	1.5	3.5
<b>Developing countries</b>	0.20	0.25	3.2	2.6	5.8
<b>TOTAL</b>			<b>8.1</b>	<b>6.5</b>	<b>14.6</b>

Source: Authors' calculations.

<sup>2</sup> 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.

What are the sources and costs of NRW? The principal components are leaks and unbilled consumption.

*Water leaks.* Every year 33 billion cubic metres of treated water physically leaks from urban water supply systems around the world, while 16 billion cubic metres 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. It is estimated that US\$15 billion is lost every year by water utilities around the world, more than a third of that by water utilities in developing countries. The scale of the problem is obvious and cannot be ignored.

*Commercial losses.* The value of water lost every year in developing countries through commercial losses—water actually delivered but not invoiced—is estimated at US\$ 2.6 billion. This is about a quarter of the total yearly investment in potable water infrastructure in the developing world. It is also more than the World Bank, the biggest water financier among international financial institutions, lends every year in aggregate for water projects in developing countries.

Although more analysis is needed, it is already clear that a sizeable portion of this commercial loss is likely to come from fraudulent activities and corruption—such as illegal connections, fraudulent meter reading, or meter tampering. This should be cause of concern for both developing countries' governments and the donor community alike. The benefits of reducing NRW are clear (see box 2).

#### **Box 2:**

##### **Clear benefits from reducing NRW**

Reducing NRW to just half the current level in the developing world would deliver the following benefits:

- Every year 8 billion m<sup>3</sup> of treated water would be available to service customers.
- 90 million people more 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 among users would be promoted by acting against illegal connections and those who engage in corrupt meters reading practices.
- Consumers would have improved service from more efficient and sustainable utilities.
- New business opportunities would be created for NRW reduction activities, with thousands of jobs created to support labor-intensive leakage reduction activities.

## **Why utilities struggle with NRW—and how the private sector can help**

NRW reduction is not a simple matter to implement, which explains why so many water utilities fail to address it effectively. New technical approaches have to be adopted and effective arrangements established in the managerial and institutional environment—often requiring attention to some fundamental challenges in the utility.

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 required action taken. Other issues concern the inherent weaknesses of water utilities in developing countries. Utilities in developing countries:

- Often operate under a weak governance and financial framework, with utility managers having to face multiple political and economic constraints.
- Must provide service to customers on a daily basis using deteriorated infrastructure.
- Often lack the proper incentives and the specialised management and technical expertise necessary to carry out an effective NRW program.
- Operate under an inadequate incentive framework.

Because the water utilities in developing countries typically lack the capacity, incentives or governance to put in place NRW reduction programs, they need external assistance.

### ***Potential for private sector involvement***

A potential source of assistance is the private sector, where involvement can take many forms, ranging from long term-public-private partnerships (PPP) to service contracts or subcontracting of certain tasks. Depending on the option chosen, the private sector can bring:

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

The key message, one too often overlooked, is that NRW must not be considered in a vacuum, but within the broader context of utility reform. The design of any NRW program needs to take into account the incentives open to the managers and staff of the program, as well as the other parties involved. Any program should ensure, as far as possible, that incentives are properly aligned with the objective of developing an efficient and effective utility that meets the needs of its consumers.

The paper excerpted here deals with *performance-based service contracting* (PBSC), a relatively new and flexible approach to the NRW challenge. Under PBSC, a private firm is contracted to implement an NRW reduction program. It is paid for services delivered and provided incentives to meet contractually enforced operational performance measures. With the proper balance of government oversight and private sector initiative, PBSC can provide an enabling environment and incentives conducive to reducing NRW, with immediate operational and financial benefits. But it is not a substitute for carrying out the broader institutional reforms necessary to promote the sustainability of the sector.

In practice, the applicability of PBSC to an NRW reduction program depends on the level of risk that the private sector is willing or able to take. Although PBSC is a relatively new concept for the water sector in the developing world, it is increasingly contemplated in other sectors as a way to improve efficiency and accountability of contracts with private providers. This is the first full study of large NRW reduction performance-based service contracts, and it considers key issues in contract design,

management practices, outsourcing options, technical assistance, risk management, and other lessons learned.

## **Case studies: reducing lost water and increasing revenue**

To date only a small number of large contracts have been let, and little information has yet become publicly available. However, the authors were able to study four significant and diverse projects. In Selangor, Malaysia, a large contract for reducing physical and commercial losses has been in place since 1998 between the water utility (at that time state owned) serving Kuala Lumpur and its surroundings, and a consortium led by a Malaysian company. In Thailand, the Metropolitan Waterworks Authority (MWA) that supplies Bangkok outsourced physical loss reduction to private contractors from 2000 to 2004. In Brazil, SABESP, the water utility that serves the São Paulo Metropolitan Region, experimented with different contractual approaches with the private sector for reducing commercial losses. And in Ireland, 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.

The following six key factors were used to evaluate these contracts:

- **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, Malaysia: the largest NRW reduction contract to date***

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. The crisis 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 m<sup>3</sup>/day. 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 an unsolicited 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 in advance, in a given time. The contractor had full responsibility for designing and implementing the NRW reduction activities with its own staff, in exchange for an agreed lump-sum payment.

The incentives for achieving the targets included (i) penalties for non-compliance of up to 5 percent of the total lump sum, and (ii) a performance guarantee of 10 percent of the contract value. The lump sum included all necessary activities like establishment of district metered areas (DMAs), pressure management, leak detection and repair, identification of illegal connections and customer meter replacement as well as the supply of all equipment and materials. The contractor was free to select the zones within the network in which to conduct its NRW reduction activities.

Phase 1 of the contract demonstrated that the concept worked: a private firm can be contracted to efficiently reduce NRW level to specific targets, provided it has the flexibility to conduct the NRW activities and the payment arrangement covers all necessary work and materials. One of the technical innovations in this case was the universal use of pressure-reducing valves (even in very low-pressure situations) not only to reduce leakage through the reduction of excessive pressures but to also protect the already repaired DMAs from upstream pressure fluctuations. The performance of Phase 1 actually exceeded the target (18,540 m<sup>3</sup>/d), achieving savings of 20,898 m<sup>3</sup>/d (approximately equally between commercial and physical losses). Twenty-nine DMAs were established with average savings of 400 cubic metres 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 m<sup>3</sup>/d.

The Phase 2 contract had a number of shortcomings but was significant in its size—the contractor was committing to an ambitious target of around 200,000 m<sup>3</sup>/d NRW reduction, something that had never been done under a PPP arrangement.

The long term sustainability of the project is not clear. The Phase 1 contract included training of the client's staff. Training on its own, however, proved insufficient for the client to maintain the improvements, and the Phase 1 zones were handed back to the contractor to operate in Phase 2. Obviously, any NRW strategy must address the issue of what to do once the contract ends.

### ***Bangkok: plugging leaks***

Water services in Bangkok are provided 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 to 3 millions m<sup>3</sup>/day between 1980 and 1990. It seemed that NRW was also reduced from 50 percent in 1980 down to about 30 percent in 1990. However, the reduction in percentage terms was mainly the result of the substantial increase in production capacity. Despite significant efforts, the volume of NRW remained stable during this period, at a high of about 900,000 m<sup>3</sup>/day.

During the 1990s, as the system's supply swelled from 3.0 to 4.5 million m<sup>3</sup>/day, NRW rose dramatically, both in percentage and in volumetric terms, reaching a peak in 1997 (1.9 million m<sup>3</sup>/day, or 42 percent), presumably caused by supply improvements and pressure increases. System input was then again reduced to below 4 million m<sup>3</sup>/day, and NRW consequently decreased and stabilised in 1999, albeit at a rather high level of 1.5 million m<sup>3</sup>/day.

Subsequent efforts have resulted in NRW reduction by 200,000 m<sup>3</sup>/day (to 1.3 million m<sup>3</sup>/day, or 30 percent) even as the system input increased to 4.2 million m<sup>3</sup>/day. A significant part of the reduction in NRW can be traced to performance contracts, which the MWA decided to award to private contractors in 2000. The objectives of these contracts were to reduce physical losses in three of the fourteen service branches of Bangkok (each 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. Both received contracts.

The design of these contracts was significantly different from 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. While each contractor was free to carry out leakage reduction activities (such as detection, pipe repairs, main replacement, installation of hydraulic equipment) as they saw fit, this was done through the use of local firms based on reimbursables (on a cost-plus basis). Instead of a lump-sum payment, as used in Selangor, the remuneration of the contractor comprised three elements: (i) a performance-based management fee to cover overhead, profits, and foreign specialist staff, (ii) a fixed fee covering essentially the cost of local labour, and (iii), the largest part of the project's cost, reimbursables for all outsourced services, work, and materials performed in the field.

In terms of technical performance, the contracts can be considered a success – but the cost efficiency of the three contracts varied widely (between US\$ 246 – 518 per m<sup>3</sup>/d water loss reduction). Physical losses in these three areas were reduced by 165,000 m<sup>3</sup>/day. To give some sense of perspective, the amount of water saved is equivalent to the volume needed to serve an additional half-million inhabitants.

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

*Advantages compared with Selangor.* There were neither arbitrary targets nor lump-sum remuneration, 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 allowed for some useful benchmarking.

*Disadvantages compared with Selangor.* The high proportion of reimbursables transfers a substantial amount of risk from the private to the public partner. Basic activities, such as leak detection, should have been included in the performance fee.

In terms of sustainability, it does not seem that the contractors put proper control and management systems in place, which 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 on.

### **Sao Paulo: payments and collections**

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. Some 40 percent of the 26,000 km network is surveyed every year.

However, customer metering and billing, including identifying and replacing under-registering meters, had been traditionally left to in-house crews. In 2004, it was estimated that SABESP was incurring daily revenue losses equivalent to one million cubic metres per day. Faced with this situation, SABESP decided to experiment with performance-based arrangements with the private sector. One of the contracts discussed below dealt with the reduction of bad debts (which is not, strictly speaking, part of NRW but has a similar negative impact on the utility's financial equilibrium); the other focused on meter replacement.

The concept of the first contract was simply to contract local private firms to negotiate unpaid invoices and collect the agreed amount. The scope of the contracts

was limited to domestic and commercial customers; SABESP still dealt directly with public institutions. Several contracts were awarded covering all of SABESP's branches. The initial contracts started in 1999 for a two-year term. The contractors were remunerated by retaining a percentage of the debt collected. That percentage was bid on by the contractors; the winning bid in each branch offered the lowest percentage figure.

The São Paulo Metropolitan Region is the industrial heartland of Brazil and industrial and large commercial customers and 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. Because meters were suspected of under-registering true levels of consumption, the strategy of the second contract was to upgrade and optimise the metering system.

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 accounts identified by SABESP. Five 36-month contracts were put in place, and the contractor was responsible for the analysis, engineering and design, supply and installation of the new meters. There was no upfront payment, and the contractor had to pre-finance the entire investment. The contractor was entitled to a payment based on the average increase in billed 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 billed volumes, 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 m<sup>3</sup> over the contract's three years, while revenues increased by US\$72 million. Of this, US\$18 million was paid to the contractors, with a net benefit to SABESP of US\$54 million.

In terms of sustainability, the contracts for reduction of bad debt have now become standard practice for SABESP. With new, properly sized, commercial customer meters installed it should now be easy for SABESP to maintain the accuracy of these meters and thus maintain the higher billed volumes from this customer category..

### ***Dublin: upgrading a very old system***

In January 1994 the City of Dublin had to deal with a severe water shortage caused by decades of underinvestment in the distribution network, combined with the absence of systematic leakage control, which had allowed physical water losses to reach very high levels. Several areas of Dublin had only 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 being lost: every day some 175 million litres 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 co-financing 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 percent to 20 percent (in volumetric terms from 175,000 to 87,000 m<sup>3</sup>/day). Given the aggressive nature of the reduction program, there was no alternative but to engage an experienced 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, rehabilitating parts of the network, and training the Dublin water utility staff. It was designed essentially as a target cost contract expressed in monetary terms. It included a bonus-and-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 UK water utility on a quality/cost basis. Significant details were left to be resolved during contract negotiations. The contractor's remuneration in the winning bid covered a management fee, technical labour, and all leak-detection equipment. This did not include the cost of leak repairs, repair materials, or network rehabilitation, which were carried out through local subcontractors and covered separately as reimbursables under what were known as "compensation events." The contract's accomplishments were significant:

Establishment of a total of 500 small DMAs (less than 1,000 connections each), covering the whole distribution network. Some 15,000 leaks were repaired and about 20 km of mains replaced. Total leakage was reduced from 175,000 m<sup>3</sup>/day to about 125,000 m<sup>3</sup>/day, and although the 20 percent leakage target was not achieved, the project was considered a success. (There was broad consensus that the original 20 percent target was not realistic given the short duration of the contract). The savings made were sufficient to end the water crisis.

In terms of sustainability, training and capacity building were 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 controls leakage as a regular part of its day-to-day operations.

### ***Lessons learned***

It is not feasible to eliminate all NRW in a water utility, but reducing by half the current level of losses in developing countries is a realistic target. Figures of such magnitude, even though based on estimates, should be enough to capture the attention of donors and developing country governments. 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.

Performance-based service contracts appear a viable way of reducing NRW losses. However, successful project implementation requires two essential and related elements: preparing good contracts and setting realistic baselines.

The case studies show various levels of quality in contract preparation, baseline setting, and—as a consequence—project effectiveness. Contract design must be clear about what the utility expects from the contractor and how it envisions success. All NRW reduction contracts should include basic guidelines concerning risk transfer, an indicator for leakage, and provisions for effective oversight by utility managers. Contracts should set viable targets and allow for flexibility in responding to challenges and opportunities.

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. Once those opportunities are known, policy makers must create an incentive framework that will encourage the private sector to deliver reductions in the most cost-effective manner, allocating risk appropriately between the parties.

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