Chapter 9

Non-Revenue Water

The terms unaccounted for water (UFW) and non-revenue water (NRW) have been widely used in the past. The use of these terms, however, has been confusing. The International Water Association (IWA) recommends the use of NRW (IWA, 2000). IWA "Best Practice" Water Balance and Terminology for NRW and its components is explained in Box 9.1 and Box 9.2. In these, UFW equates to Water Losses. Accordingly, throughout this book, reference is made wherever possible to NRW, not UFW.

Spaghetti network repairs and leaks

A. Components of Non-Revenue Water

Unbilled Authorized Consumption can include water used for fire fighting or free water distributed at standpipes or provided to religious institutions.

Apparent Losses comprise unauthorized consumption and metering inaccuracies. It is estimated that in Asian cities 50–65% of NRW is due to apparent

Box 9.1 International Water Association Water Balance

The following are definitions of principal components of IWA water balance.

- ***System Input Volume*** *is the annual volume put into the part of a water supply system that relates to water balance calculation.*
- ***Authorized Consumption*** *is the annual volume of metered and/or non-metered water taken by registered customers, water suppliers, and others who are implicitly or explicitly authorized to do so for residential, commercial, and industrial purposes. It includes water that is exported.*
- ***Water Losses*** *can be identified by calculating the difference between system input volume and authorized consumption. They consist of apparent losses and real losses.*
- ***Apparent Losses*** *result from unauthorized consumption and all types of inaccuracies associated with metering.*
- ***Real Losses*** *result from losses at mains, service reservoirs, and service connections (up to the point of customer metering). The annual volume lost through all types of leaks, bursts, and overflows depends on their individual frequencies, flow rates, and duration.*
- ***Non-Revenue Water*** *is the difference between system input volume and billed authorized consumption, and it consists of the following:*
  - *Unbilled Authorized Consumption (usually a minor component of water balance),*
  - *Apparent Losses, and*
  - *Real Losses.*

Box 9.2 "IWA Best Practice" Water Balance and Terminology				
System Input Volume	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption (including water exported)	**Revenue Water**
			Billed Non-metered Consumption	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	**Non-Revenue Water**
			Unbilled Non-metered Consumption	
	Water Losses	Apparent Losses	Unauthorized Consumption	
			Metering Inaccuracies	
		Real Losses	Leakage on Transmission and/or Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to Customers' Meters	

losses. Unauthorized consumption means illegal use, and this could be (i) sole illegal connections, (ii) illegal connections to properties that also have legal connections,[10] or (iii) illegal connections for the purpose of selling water. Metering inaccuracies can include malfunctioning water meters, estimated water consumption (when meters are not working), and misreading water meters.

Real Losses comprise leakage from transmission or distribution mains, leakage and overflow from utility storage and balance tanks, and leakage in reticulation systems (especially service connections) up to the point of metering. Experience has shown that most leakage results from service connections, and to a large extent this is due to poor construction.

B. Consequences

The issues related to high NRW rates are (i) consumers paying for inefficiencies of water utilities, (ii) a precious and scarce resource being wasted, and (iii) unnecessary investments in production. Another important consideration is that high NRW rates equate to poor governance, which results in low utility staff morale. From the consumers' point of view, those who have illegal connections or have estimated actual consumption below real consumption are cheating those who pay for water. Poor governance is at the root of the problem. See Figure 9.1 for an illustration of the extent of NRW in Asian cities.

Illegal connection in Nepal

[10] I once watched many residents on one street (in Manila) divert water for a short time from their illegal to their legal connections.

Linkage of Non-Revenue Water to Low Service Coverage

Where there is low coverage with piped water there is also likely to be high NRW. It is possible that those with vested interests condone the illegal sale of utility water to SSWPs at high prices (low volumes). The total revenue obtained from this source may be of the same order of magnitude as the official sale of water by utilities. Someone should ask where the revenue generated through illegal sales to SSWPs goes, because the answer to that question might explain why the status quo (the urban poor not receiving service) has remained for so long.

Service connection leakage

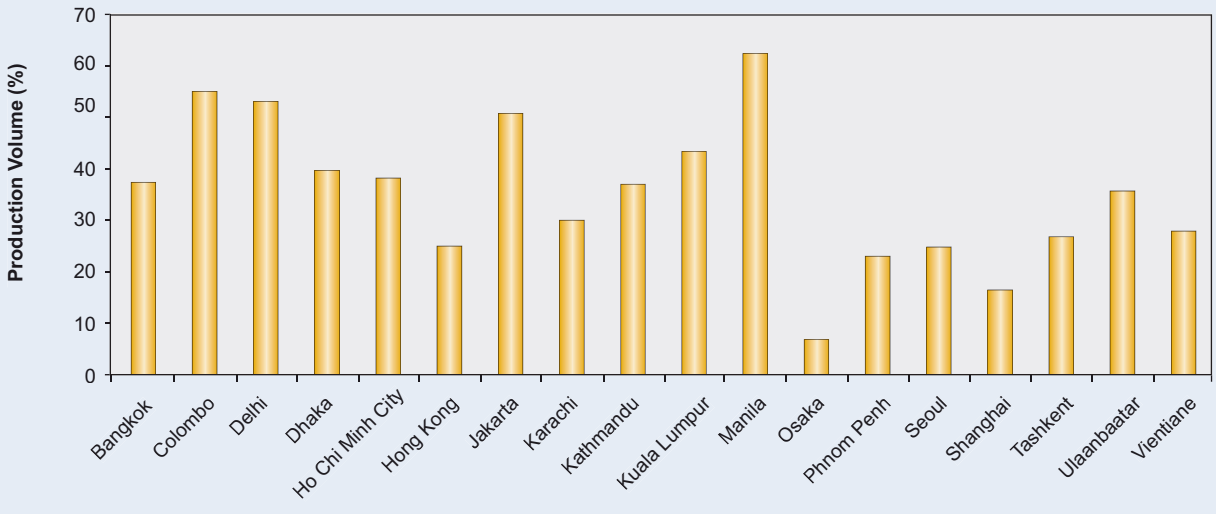
C. Reducing Non-Revenue Water

The benefits of reducing NRW include:

- need for less water to be produced, treated, and pumped, translating into the postponement of the expansion of capacity—producing less water also translates immediately into cost savings on O&M, due to savings in energy and treatment costs;
- reduction in apparent losses, which will result in more water being billed and more revenue for utilities—it has also been shown that water metering and adequate rates reduce wasteful consumption, which will likely decrease total consumption;
- adequate understanding of consumption patterns, which will allow utilities to optimize distribution systems;
- better knowledge of real consumption, which will improve demand projections; and
- reduced sewage flows and pollution.

These benefits depend on adequate pricing of water resources and services. Subsidies for water extraction, discharge of wastewater, capital investment, and operation of water supply systems lower the cost of water as perceived by utilities and thus remove an incentive to reduce physical losses. Low

Figure 9.1 Non-Revenue Water in Asian Cities (2001)



water rates for consumers do not encourage utilities to meter their water consumption and detect and deter unauthorized water use. Moreover, low rates fail to provide consumers with an incentive to deal with leaks and wastage beyond their meters.

It is often said that there is no point in reducing NRW below about 20% of production, because the costs outweigh the benefits. An example from Singapore seems to disprove that theory (see Box 9.3).

Mapping

The distribution systems of most Asian cities are very poorly mapped. Only when these are well mapped can the hydraulics be properly calculated and limitations on extensions to the distribution systems be properly controlled. Now, with global imaging tools and computerization, this work can be more easily accomplished and maintained. Good records and public scrutiny (with the help of neighbors) will help eliminate illegal connections.

Control Measures

Programs for controlling NRW should tackle at least the following three main causes of loss: (i) metering inaccuracies, (ii) unauthorized consumption, and (iii) leakage. Methods of controlling leakage include passive control, regular sounding, district metering, waste metering, combined district and waste metering, and pressure control. Selecting the most appropriate method would depend on the level of leakage, the cost of leakage, and the cost-effectiveness of each method.

System leakage

Box 9.3 Case Study Singapore (pop. 2.8 million)—Public Utilities Board

- *NRW was reduced from 10.6% in 1989 to 6% in 1994.*[a]
- *Metering of production and consumption is 100%.*
- *Meter accuracy is very high. Production meters are calibrated every month. Domestic consumer meters are replaced every 7 years and industrial meters every 4 years.*
- *Volume of water used for fire fighting is estimated or measured and fire departments are billed.*
- *Commercial system is highly reliable and controls are in place to prevent tampering.*
- *Billing complaints are dealt with promptly.*
- *High and low consumption patterns are investigated.*
- *Average water rates are close to the incremental cost of water.*
- *The entire distribution system is surveyed for leaks every year.*
- *Water districts can be fully isolated to monitor for leaks. Distribution pipes are cement lined to reduce corrosion and are replaced if the number of breaks exceeds three per kilometer per year.*
- *House connections are made of stainless steel or copper.*
- *Certified plumbers do in-house repairs and installations.* (Yepes, 1995)

[a] NRW was reduced to 5% in 2000.

Points to Remember

- Accountability must be high at all levels.
- Water services must be adequately priced.
- Reducing commercial losses is very important, because it helps improve the revenue stream almost immediately.
- Reliable information on production and consumption is necessary.
- NRW is the result of a combination of factors, not of a single one.
- NRW programs must be institutionalized and not be the result of sporadic exercises associated with the availability of grants or loan financing.
- NRW cannot be addressed in isolation. An enabling environment must be created. This means that (i) utilities must have autonomy in terms of management, and they need competent and motivated employees; (ii) tariffs must be adequate, which will result in cost and benefit incentives to reduce NRW; and (iii) good governance must be practiced.

The proportion of all accounts that show an estimated billing amount or a minimum figure is a good indication of the whole discipline of accountability. These days, with computerized accounts, there are few excuses for not identifying and correcting these inadequacies. Amnesties to ferret out illegal connections, public advertising, and convictions in courts of law for those discovered with illegal connections (who did not come forward when amnesty was offered) may be implemented.

It might surprise some to know that in cities of developing countries, under projects assisted by development agencies, the first effort to reduce NRW often involves the purchase of leak detection equipment. This is the developed country approach, and in most cases it has little relevance when solving developing country problems. It is far more realistic to go out and repair all visible leaks (of which there are usually plenty) and carefully scrutinize and accurately meter large water consumers. A caretaker approach to O&M and reducing NRW is shown in Box 9.4.

Pipe Replacement

In Singapore and Tokyo galvanized iron and polyvinyl chloride (PVC) service connections have been replaced with stainless steel service connections, and NRW levels in these cities (4% and 8% respectively) demonstrate the success of this approach. Singapore, Tokyo, and other cities also have programs for replacing asbestos cement pipes in distribution systems, as pipe breaks have increased over time.

Benchmarking

Benchmarking NRW is useful, as it enables utilities to compare themselves with others. Moreover, benchmarking helps utilities compare their performance during one period with their performance during another. The leakage component can be measured in other ways—as water lost per kilometer of distribution and as water lost per connection—but this assumes that NRW does not have a high component of apparent losses.

Summary Remarks

Reducing NRW is not technically difficult. It is, however, challenging in a governance sense. Illegal connections can only be eliminated when utilities have autonomy and discipline, and when they are accountable to regulators and the public. In addition, utility employees need genuine incentives to do their jobs and replace the incentives they have made for themselves through illegal connections, false meter reading, etc. (see Phnom Penh case study in Appendix 2). The status quo needs to be overturned. Comprehensive audits of water and service levels are needed and links between NRW, low service coverage, and SSWPs need to be explored. When tariffs are much higher, consumers will put pressure on operators to eliminate leaks and chase illegal connections. Good organizational development is needed to take advantage of autonomy and deliver accountability.

Box 9.4 Caretaker Approach to Operation and Maintenance and Reducing NRW

Rationale: Legal and technical approaches to combating NRW have met with limited success. Generally, utility staff will only appear when called out in an emergency or a crisis situation, rather than show a daily presence in a given locality. The proposed caretaker approach would add a social dimension to addressing the problem. It is based on managing water supplies at the lowest practicable level and on maintaining a good utility and consumer interface. It is particularly suitable for those developing countries without shortages of relatively cheap manpower.

Definition: The caretaker approach is essentially one in which the whole of a distribution system is divided into zones, each containing about 500 connections. A caretaker is appointed to be responsible for all water supply activities within a given zone. The concept is not new. In fact, it is employed in Tokyo and is, to some extent, also used effectively by one of the concessionaires in Manila. An SSWP in Manila uses this approach to manage its system by assigning one *aguador* to every 100 connections.

Institutional Framework: A caretaker who lives in the locality is given responsibility for a water distribution zone. The caretaker will report to an O&M supervisor located at a nearby maintenance depot. The caretaker's area of responsibility is small enough that it can be walked in its entirety once per week. This individual will lease an office from a resident in his or her zone of responsibility and have access to a telephone at that point (or will use a mobile phone). The O&M supervisor (an engineer) will be responsible for 10 caretakers and not more than 5,000 connections.

Caretaker Duties: The caretaker is expected to develop a friendly relationship with the people living in the zone of responsibility. He or she will do the following.

- Keep a daily diary of all activities in the zone.
- Be responsible for mapping the distribution system, including all connections.
- Be responsible for accurately metering all consumer connections and arranging for meter replacement when necessary.
- Analyze billing records and collections monthly, investigate high and low consumption and tardy payments, and report total consumption each month.
- Report leaks to be repaired and record the dates the repairs were effected.
- Report maintenance or new work requested and completed.
- Record and follow up on consumer complaints.
- Inspect plumbing in all households and assist with repairs, where feasible.
- Disseminate to consumers notices of interruption of supply for maintenance purposes and information concerning water tariffs, water consumption and conservation, demand management, hygiene education, and utility performance.
- Report alternative sources of water used by both utility customers and noncustomers.
- Report hours of service and pressure to the zone (day and night).
- Report numbers of persons in each household in the zone each year.
- Read district flow meters and pressure gauges daily.
- Inspect the entire zone on foot weekly.

O&M Supervisor Duties: The O&M supervisor is expected to support the caretaker in the following manner.

- Provide timely support and quality control on maintenance and repairs.
- Visit and talk with each caretaker daily.
- Review caretaker diaries weekly and provide comments and guidance.
- Inspect with each caretaker his or her zone monthly.

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Box 9.4 continued

- Encourage competition and incentives among caretakers for good performance.
- Comment on all caretaker reports before submitting them to the head office.

Conclusion: In this age of information technology there are few excuses for not having up-to-date data on every connected and nonconnected household in a given water service area. If this information is appropriately analyzed, it will be relatively easy to trace illegal connections, defective meters, and incorrect meter reading. At the same time, with the ability of caretakers to get to know the people in their zones, and with the timely use of amnesty periods, it should be possible to flush out most illegal connections. By examining individual zones and comparing these with others, it should be possible to identify quickly any problem areas.

Non-Revenue Water (Problems) in a Nutshell

- NRW includes water not billed as a result of leakage, illegal use, inadequate measurement, and free (authorized) use.
- NRW averages 30% of production in Asian cities, but ranges from 4% to 65%.
- High NRW is connected to low piped water coverage.
- There is a need to determine whether physical losses (leakage) are maintained to mask the illegal use and sale of water.
- Illegal sale of water from utilities can generate revenue equal to legal sales.
- Consumers pay for utility inefficiencies.
- A precious and scarce resource is being wasted.
- Unnecessary investments in production are made.

Non-Revenue Water (Solutions) in a Nutshell

- Governance and tariffs must be tackled first.
- Leak detection equipment comes last, not first.
- Repair visible leaks.
- Make utility staff responsible for small zones (caretakers).
- Meter all production and consumption properly.
- Add district metering.
- Provide incentives for utility staff performance.
- Explore links to water vendors.