WATER GLOBAL PRACTICE

Better Use of Capital to Deliver Sustainable Water Supply and Sanitation Services

Practical Examples and Suggested Next Steps

Bill Kingdom, David Lloyd-Owen, Sophie Trémolet,
Sam Kayaga, and John Ikeda

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Acknowledgments

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The team would like to thank peer reviewers Gerard Soppe (Sr. Water Supply and Sanitation Specialist, Water Global Practice), Luis Andres (Lead Economist, Water Global Practice), Alex McPhail (Lead Water Supply and Sanitation Specialist, Water Global Practice), and Pier Mantovani (Lead Water Supply and Sanitation Specialist, Water Global Practice) for their practical and insightful comments. The team would also like to thank Alex Bakalian (Global Lead, Water Supply and Sanitation, Water Global Practice) for his guidance in finalizing the document.

Executive Summary

The Sustainable Development Goal (SDG) targets for water supply, sanitation, and hygiene (WASH) are much more ambitious than the WASH Millennium Development Goal (MDG) targets, aiming for better service quality and universal coverage. According to the World Health Organization/United Nations Children's Fund (WHO/UNICEF), some 3 in 10 people worldwide, or 2.1 billion, lack access to safe, readily available water at home, and 6 in 10, or 4.5 billion, lack safely managed sanitation (2017a).

The costs of meeting the WASH targets by 2030 will be substantial and much higher than sector investment levels during the MDG era (2000-15). According to recent studies commissioned by the World Bank, meeting SDG targets on extending access to water and sanitation services alone will require average capital expenditure of US$114 billion per year between 2015 and 2029, which is several times past levels of investment in the sector. At the same time, governments and donors already invest about $16 billion a year in the sector.

The immense scale of the SDG financing gap calls for innovative solutions. In addition to finding additional funding from traditional sources (taxes, tariffs, and transfers), and perhaps from non-traditional sources (for example, carbon finance) to fill the gap, another approach is to explore ways to deliver the needed infrastructure more efficiently and effectively (capital expenditure efficiency) to reduce the gap—the focus of this report. Regardless of the SDGs, the approaches presented here can be applied to existing government/donor investment to maximize their impact—delivering more benefits from the existing levels of investment.

Capital expenditure efficiency (CEE)—the efficient and effective use of capital—is less documented compared to operational efficiency and is the relationship between the costs of building a portfolio of assets relative to the number of people served and the quality of service provided. Although the need for improving operating efficiency is frequently highlighted (for example, by emphasizing the need to reduce water or energy losses) and readily evaluated (this year's costs compared to previous years), the potential scope for generating capital cost efficiencies is poorly understood, frequently overlooked, and more difficult to evaluate, even though the scale of such potential savings can be significant—in fact, capital costs and operating costs are equally important when considering the full cost of service delivery.

This study investigates the ways in which CEE can be improved in the water and sanitation sector. It collected a range of case studies that show the "art of the possible" rather than some theoretical construct. Even within this narrow remit, the report cannot be considered encyclopedic—there are many more examples that could surface from a deeper and more comprehensive study. The study also does not attempt to quantify the total savings possible through increasing CEE, nor does it look at upstream capital allocation and the opportunities to improve outcomes through better prioritization of available funds. Although it identifies examples of CEE, the report does not attempt to identify the root causes for why such examples are not more widely adopted by practitioners. Is it through ignorance, inertia, incentives, or some other reasons?

The report does, however, shine a light on a range of practical opportunities available to governments and donors to introduce greater CEE into the sector. The goal is to provide sufficient material to gain the attention of policy makers. This would lead into a more comprehensive analysis of the opportunities for CEE and how it can be operationalized through policy and regulatory incentives or through improved capital planning procedures.

However, almost all the examples presented in this report show capital savings in the order of 25 percent or more compared to traditional solutions. This alone should give policy makers, donors, and utility managers pause for thought and encourage them to seek ways to develop CEE in their sectors, projects, or utilities. A 25 percent improvement in CEE would allow existing investment levels to deliver a 33 percent increase in benefits.

As noted in the report, a contributing factor to the general lack of attention to CEE is the perception that capital funding in many developing countries is "free." This is an erroneous assumption caused by the fact that WASH capital assets in developing countries are often funded by public budgets or official development finance (ODF),[1] with funding provided to the end user at no or low cost. In developed countries where utilities account for the full cost of service delivery, the debt service to repay the loan associated with capital costs are significant. For example, for water utilities in England and Wales (United Kingdom), capital costs amount to an average of 49 percent of total costs.[2] Utility managers and planners in developing countries would likely be more attuned to improving CEE if they were faced with financing the full cost of asset creation.

In summary, this work provides a "taster" on CEE and its importance in the sector. As a result, no firm set of recommendations are provided[3] except to exhort practitioners to be more active in considering opportunities for CEE in their policies, sector investment plans, and project designs.

However, the examples presented here should be sufficient to encourage the initiation of a deeper and more comprehensive analysis of CEE. This might cover a broad range of issues including the following:

- Clarification of the role of CEE in sector strategic planning—including capital allocation and prioritization
- Creation of a more nuanced analysis of the relative importance of capital versus operating costs at the sector and subsector levels
- Determination of the potential cost reductions in meeting the SDGs when CEE is more widely applied
- Determination of the increased benefits that would flow from applying CEE to current investments undertaken by governments and donors
- A more extensive set of case studies to broaden and deepen examples of approaches that have been adopted to deliver improved CEE
- A root-cause analysis looking at capacity, governance, and incentives to better understand the obstacles to widespread adoption of the CEE approach
- Proposition of different approaches by which CEE could be actively introduced to government and donor policies—including line ministries, finance ministries, regulators, local governments, and service providers
- Development of incentive models that will encourage adoption of those policies by practitioners
- Consideration of more systematic data collection on capital costs for the sector, which would provide practitioners with better benchmarks when assessing the costs of proposed capital solutions

Notes

1. *Official development finance* (ODF) is defined by the Organisation for Economic Co-operation and Development (OECD) as the sum of bilateral official development assistance (ODA), concessional aid, and nonconcessional resources from multilateral sources, as well as bilateral other official flows (OOFs) made available for reasons unrelated to trade.
2. Author's compilation based on annual performance reviews for 2016–17 for the 10 water and sewage companies and the five main water-only companies.
3. Interim suggestions are, however, provided in appendix A, pending a more comprehensive analysis.

Abbreviations

AYTO	Zaragoza City Council
AMP	asset management plan
CAPEX	capital expenditure
CAPMANEX	capital maintenance expenditure
CEE	capital expenditure efficiency
CWIS	citywide inclusive sanitation
DB	design-build
DBB	design-bid-build
DBO	design-build-operate
FSM	fecal sludge management
GWI	Global Water Intelligence
IDA	International Development Association
iDE	International Development Enterprises
ILI	Infrastructure Leakage Index
IOT	internet of things
LPCD	liters per capita per day
MDG	Millennium Development Goal
MLD	million liters per day
NPV	Net Present Value
NGO	nongovernmental organization
NRW	nonrevenue water
O&M	operations and maintenance
ODA	official development assistance
ODF	official development finance
OECD	Organisation for Economic Co-operation and Development
Ofwat	Office of Water Services, UK
OOF	other official flows

OPEX	operating expenditure
OPP	Orangi Pilot Project
OPP-RTI	Orangi Pilot Project-Research Training Institute
PBC	performance-based contract
PR	price review
ROI	return on investment
SAWACO	Saigon Water Corporation
SDG	Sustainable Development Goal
SDG6	Sustainable Development Goal 6
TOTEX	total expenditure
UNICEF	United Nations Children's Fund
URWSS	Uttarakhand Rural Water Supply and Sanitation
US$	U.S. dollar
VE	value engineering
WaSC	water and sewerage company
WASH	water supply, sanitation, and hygiene
WDM	water demand management
WHO	World Health Organization
WSP	Water and Sanitation Program
WTP	willingness to pay

Chapter 1
Introduction

Background

The Sustainable Development Goal (SDG) targets for water supply, sanitation, and hygiene (WASH) are much more ambitious than those of their predecessor Millennium Development Goals (MDGs). SDG Target 6.1 for water supply envisages universal access to "drinking water from an improved water source which is located on premises, available when needed and free of microbiological and priority chemical contamination" (World Health Organization [WHO] 2017). This is referred to as *safely managed*. Intermediate levels of water services are also recognized: *basic* (that is, an improved water source accessed within 30 minutes of collection round-trip time) and *limited* (that is, an improved water source with a collection round-trip time of more than 30 minutes). SDG Target 6.2 for sanitation services is similarly categorized as universal access to services that are *safely managed* (that is, use of improved facilities not shared with other households and excreta are safely disposed of); *basic* (that is, use of improved facilities that are not shared) or *limited* (that is, use of improved facilities that are shared).

The costs of meeting the WASH SDG targets by 2030 will be substantial with much higher investment levels compared to those in the MDG era (2000–15). A study carried out for the World Bank estimated the costs of achieving safely managed WASH targets as prescribed by Targets 6.1 and 6.2. at US$114 billion per year and split by subsectors as shown in table 1.1 (Hutton and Varughese 2016).

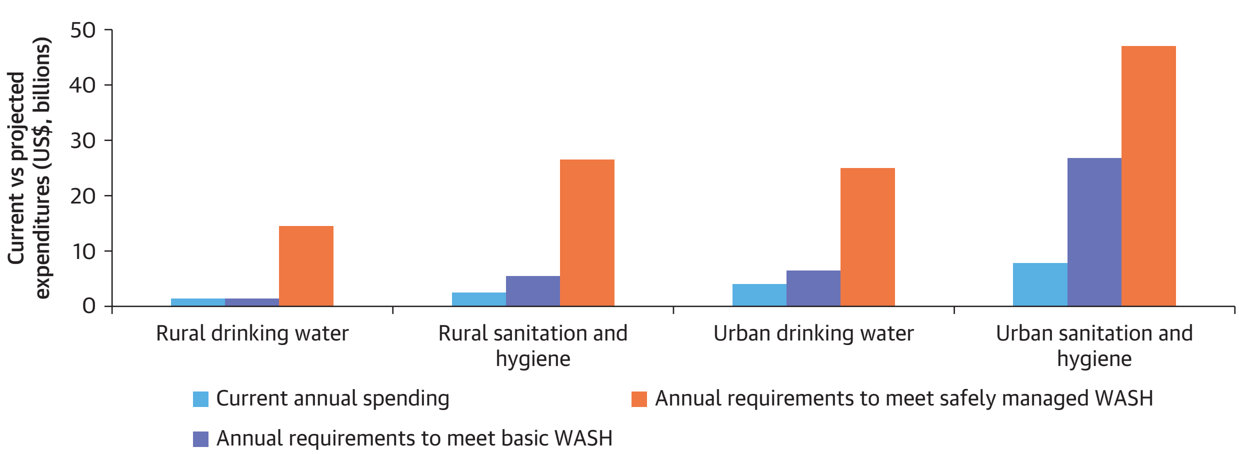
Figure 1.1 shows the projected WASH sector funding requirements compared to current flows. Recent funding levels are not adequate to meet the capital costs of

TABLE 1.1. Estimated Investment Needs to Meet SDG 6.1 and 6.2

Investment needs (US$ billion/year)	Urban water	Urban sanitation	Rural water	Rural sanitation	Total
Total capital expenditure	30	42	15	27	114

Source: Hutton and Varughese 2016.

FIGURE 1.1. Financing Gaps for Achieving SDG Targets 6.1 and 6.2



Source: World Bank Group/UNICEF 2017a.
Note: WASH = water supply, sanitation, and hygiene.

providing SDG "basic" WASH services and would have to be increased several times to meet the cost of "safely managed" services.

Objective of This Report

With governments and donors already investing large amounts of money into the water supply and sanitation sector (approximately US$16 billion per year), and with the SDG investment needs being several times higher, some basic questions need to be asked by practitioners and policy makers alike.

First, do governments get full value from the investments they currently make?

Second, how will the massive SDG financing[1] gap be bridged?

The answer to the first question is probably no—based on anecdotal observations around the world of assets that are overdesigned, that are underutilized, or that do not reach their full economic life. However, it is also true that little attention is paid to this important aspect of development. Practitioners frequently discuss improving operational efficiency but, given that capital costs amount to some 50 percent of total costs of service provision, a better understanding of the opportunities to reduce wasteful capital spending is equally vital for the sector—especially when investment funding is constrained. For governments and donors, the inefficient use of capital means that social and economic benefits are foregone and that governments' (or service providers') economic (or financial) rates of returns are reduced. In other words, more efficient use of existing finances could deliver significantly better results.

The answer to the second question requires a broader response that might be considered in three possible solutions:

- Mobilize additional sources of finance and thus fill the financing gap.
- Lower the capital costs of meeting the SDGs and thus reduce the financing gap.
- A mix of the two to both reduce and fill the financing gap.

The World Bank has written extensively on the scale of the financing gap and opportunities to fill it (Bender 2017; Kolker and others 2016; Leigland, Trémolet, and Ikeda 2016; Winpenny and others 2016; World Bank Group/UNICEF 2017a, 2017b), culminating in its omnibus report "Easing the Transition to Commercial Finance for Sustainable Water and Sanitation" (Goksu and others 2017). This report, however, focuses on the opportunities to lower capital costs to meet the SDGs and thus reduce the financing gap. It presents examples from around the world of opportunities for capital expenditure efficiency (CEE) in the water and sanitation sector—the relationship between the costs of building a portfolio of assets relative to the number of people served and the quality of service provided.

Note that in this report, the word *efficiency* captures both effectiveness and efficiency of investment—in other words was the right solution selected in the first place and was it then delivered at least cost? The insertion of the word *expenditure* is included to reflect that the report is focused predominantly on whether capital, once allocated, has been used effectively/efficiently. The upstream allocation of capital may in itself be inefficient, thus further reducing the benefits that might have come from that capital.

The report provides practical insights for policy makers, project designers, and donors on how capital investment costs can be reduced while still achieving the required outcomes through a range of different strategies. However, the report does not claim to be encyclopedic (there are many other opportunities for CEE), nor does it attempt to quantify the total savings possible through increasing CEE (for example, to meet the SDGs), nor does it look at capital allocation and the opportunities to improve outcomes through better

BOX 1.1. Change of Focus by Ofwat, the Water Services Regulator in England and Wales

Ownership of the 10 water and sewage utilities in England and Wales changed in 1989 from being publicly owned utilities to water and sewerage companies by floatation of shares on the stock market (the 17 water-only companies in England were already in private ownership at that time). The water services regulation authority in England and Wales was set up at the same time: Ofwat is a non-ministerial government department that is mainly responsible for the setting of tariffs for water and sewerage services, taking consideration of proposed capital investment projects. In its early stages, Ofwat instituted separate performance incentive structures for capital expenditure (CAPEX) and operating expenditure (OPEX), which enabled emphasis of the importance of capital expenditure efficiency (CEE) when private sector participation was introduced to the utilities services sector. Twenty or so years later, as the private water utilities climbed the capital development maturity ladder, there was a need to consider CAPEX, capital maintenance expenditure (CAPMANEX), and OPEX together following a total expenditure (TOTEX) approach.

Source: https://www.ofwat.gov.uk.

prioritization of available funds at the national or service provider level.

The report does, however, shine a light on a range of practical opportunities available to governments and donors to introduce greater CEE into the sector. The goal is to provide sufficient material to gain the attention of policy makers. This would lead to a more comprehensive analysis of the opportunities for CEE and how they can be operationalized through policy and regulatory incentives, or through improved capital planning procedures.

The authors are aware that many practitioners believe that efficiency should be determined through minimizing whole life (operating and capital) costs. However, this is a relatively sophisticated approach—hence the separation of operational and capital costs (and their associated efficiencies) is considered appropriate at the current time. The approach to regulation of the water sector in England and Wales adopted such a differentiated approach for almost 20 years before moving to a more integrated "total cost" approach. This reflected the reality that, early in the regulatory regime, there were many efficiencies to be gained in both operating and capital costs. Only once the inherited inefficient capital and operating practices were reduced was the move to more sophisticated approaches warranted (box 1.1). This seems to be equally applicable to the situation faced today in developing countries

The remainder of the report is structured as follows:

- Chapter 2—Overview of capital efficiency, including definitions, concepts, and application.
- Chapter 3—Approaches to improving CEE in the water sector based on international examples.
- Chapter 4—Conclusions and suggestions for ways forward to increase the adoption of CEE within the sector.

Note

1. In this case, *financing* strictly includes both *funding* (taxes, transfers, and tariffs) and *financing* (borrowing is repaid using the different sources of funding). For simplicity, the term *financing* is used in this report to mean—interchangeably by context—funding, financing, or both.

Chapter 2
Overview of Capital Efficiency

Definitions and Concepts

Capital efficiency is a term commonly used in the financial industry and is defined as a financial ratio that measures the profitability and efficiency with which capital is applied in a sector (Firer and Williams 2003; Enqvist, Graham, and Nikkinen 2014; Muritala 2018). Thus, capital efficiency deals with the understanding of the ratio of output in comparison with the amount of capital investment involved in maintaining the operations of a business or a sector (Tatum 2018). In simple terms, capital efficiency is the ratio of output divided by capital expenditure. With respect to a private company, PricewaterhouseCoopers defined it as "the measure of a company's ability to select, deploy, and manage capital investments that maximize shareholder value" (2016).

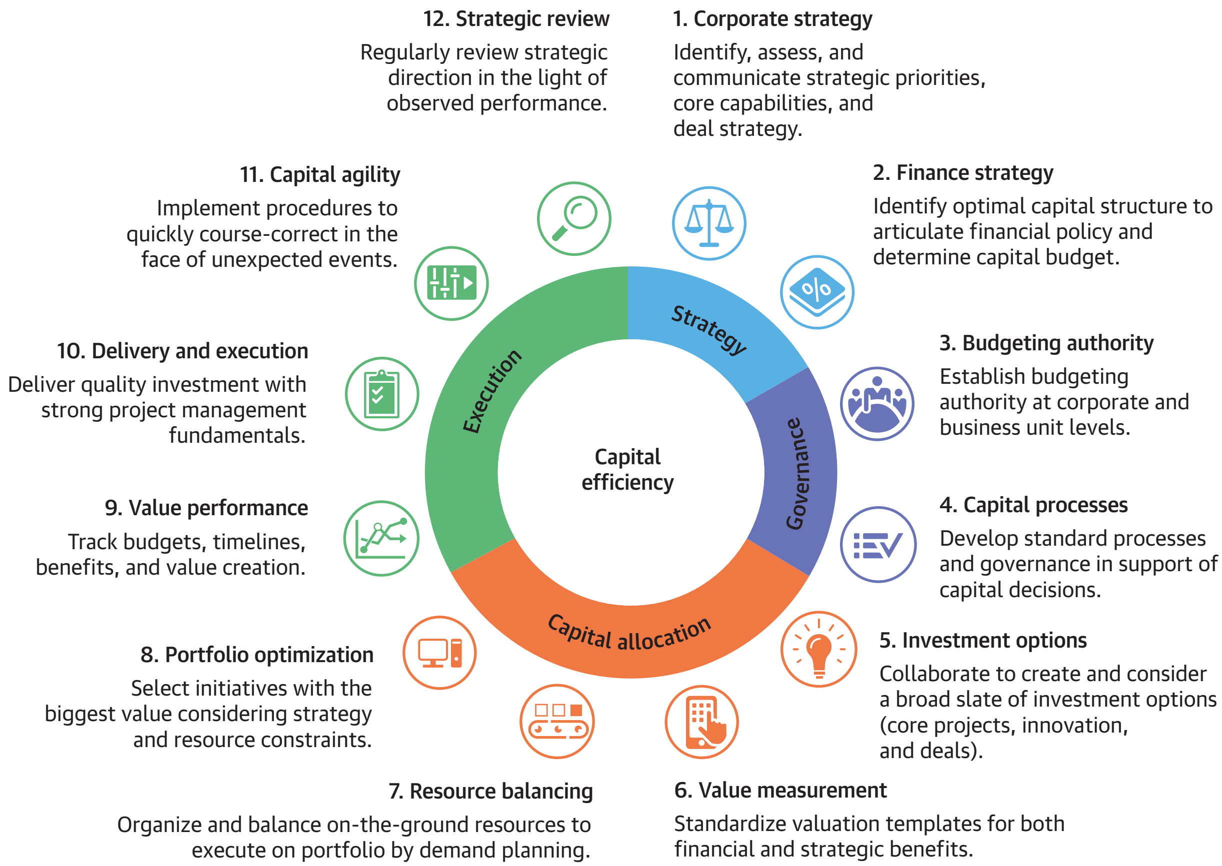
This report has focused on capital expenditure efficiency (CEE), a narrower focus on the effective and efficient use of allocated capital, rather than the broader definition of capital efficiency previously noted, which would include allocation efficiency, expenditure efficiency/effectiveness, and financing efficiency. As a result, this chapter, which is based predominantly on a literature review, frequently (but not exclusively) uses the term *capital efficiency* as presented in the original material sourced during the review.

It might be argued that CEE should emerge anyway from good engineering practice. The role of the designer is, after all, to find solutions that meet the client's needs at minimum costs through the comparison of viable options. This, however, is clearly not the de facto modus operandi of the engineering sector. This gap led to the advent of value engineering (VE), a methodology developed in the United States during World War II by Lawrence Miles, who worked for the General Electric Company (Chartered Institute of Building [CIOB] 2018). In contrast to mere cost reduction, VE is a focused, systematic approach used by a multidisciplined team to analyze a system, service, or facility to identify the best way to manage essential functions while lowering cost—that is, leading to improvement of the value of a product, process, or service. Value is the ratio of function to cost. Therefore, lowering cost while maintaining function increases value (Bisk). CEE is a key contributor to VE. The main purpose of the application of CEE is optimization—that is, getting more for less.

To exploit capital efficiency opportunities requires practice, clear objectives, and ambition by "thinking big" about improving a sector (Jacobsohn 2015). Capital efficiency measures start with corporate strategy and require agility and foresight to pursue, abandon, scale up/down, or defer capital projects. Accordingly, PwC (2016) derived 12 elements of capital efficiency that hinge on the four pillars of strategy, governance, capital allocation, and execution, as shown in figure 2.1. The figure shows a process-based framework that could be adopted by an organization to assess opportunities for capturing value and achieving maximum benefits from these four pillars. This framework was developed for the energy sector, but it could be adapted for application in other sectors. It highlights the importance of (a) defining capital efficiency, how critical it is in today's market, and where there are opportunities to improve; (b) identifying measures for capital efficiency and how they are implemented throughout the asset lifecycle; (c) determining how efficiently an organization allocates its capital to take advantage of opportunities to optimize return on capital employed; and (d) addressing the shift from capital efficiency being driven by capital selectivity.

Capital efficiency forces innovation, delivers better returns, and is essential to a sector's fundamental

FIGURE 2.1. Process-Based Framework for Capital Efficiency



Source: PwC 2016.

financial health and operational efficiency (Hawley 2018; Verhage 2016). On average, 30 percent of the potential value of public investment is lost due to inefficiencies in the investment process. Closing this efficiency gap through capital efficiency measures could substantially increase the economic dividends from public investment, especially in developing countries. The inadequate application of capital efficiency in developing countries has led to wasteful public investment spending, including investment for "white elephant" projects that are characterized by large cost overruns, time delays, and inadequate maintenance (International Monetary Fund 2015).

Selected Examples of Application in Other Sectors

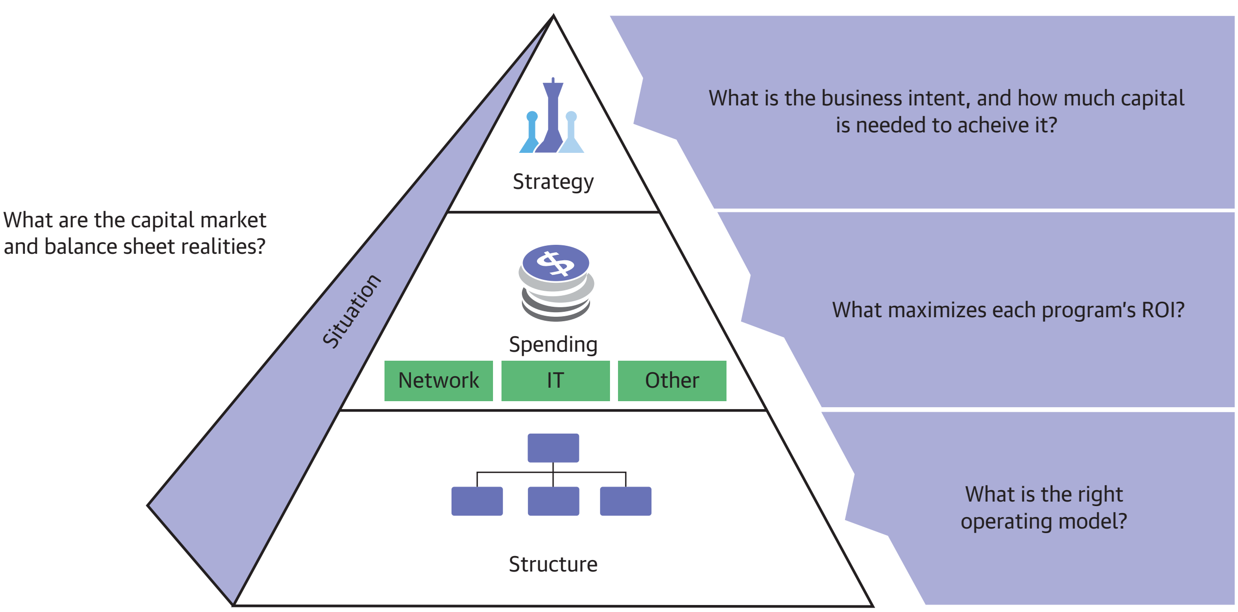
There is general awareness of capital efficiency in many sectors, although its application can be challenged by negative perceptions including: (a) capital efficiency application is not practical in the labor market; (b) capital efficiency discourages good growth; and (c) there is needless complexity in the application of capital efficiency (Soberg 2013). Literature on capital efficiency indicates that research on capital efficiency and its application have been limited to efficiency of capital markets, intellectual capital efficiency, and production capital efficiency (Hudson, Dempsey, and Keasey 1996; Costa 2012; Ederer 2015), with less research on capital efficiency and its application in infrastructure sectors, such as roads and water.

Capital efficiency measures have, however, been developed and used by many industry players to avoid short-term bias and to provide stakeholders with the long-term ability of a sector to create more value (Baumast 2017). Prudent management of assets in all areas, particularly investment in assets and payment management, are essential for the long-term success of any sector. An effective capital efficiency application depends on a better understanding of the assets, their value, and their performance in a sector.

Amec Foster Wheeler, a global consultancy, engineering, and project management company mainly involved in energy, mining, chemical processing, and environmental infrastructural engineering, applied capital efficiency principles to the preliminary design of a multibillion-dollar project of legal potash in Saskatchewan, Canada, and made 20 percent savings in the capital cost (Amec Foster Wheeler 2016). They did this through innovation, zero-based design, integrated execution, and connected estimating using a variety of tools, such as VE, process optimization, supply chain management optimization, and modularization/pre-assembly.

Bain & Company, a global management consultancy headquartered in Boston, Massachusetts, developed a comprehensive approach for capital efficiency application that addresses a telecom company's situation, strategy, spending, and structure (Blum and Lowe 2016), which are termed the four S's of capital effectiveness. Their framework (figure 2.2) recognizes that companies operate in different *situations* and should analyze the range of factors that determine the right level of capital intensity. Senior management should make a *strategy* that focuses capital investments in the geographies and customer segments where they have made an explicit decision to play to win. The key to

FIGURE 2.2. The Four S's of Capital Effectiveness



Source: Blum and Lowe 2016.
Note: ROI = return on investment.

unlocking larger returns is disciplined consideration of *spending* alternatives. Finally, it is important to *structure* the operating model in a way that will optimize returns.

Capital Expenditure Efficiency in the Water Sector

As has been highlighted in the introductory sections, it will be essential to consider reducing capital costs through improved effectiveness/efficiency as part of the overall water supply, sanitation, and hygiene (WASH) sector financing strategy to meet the SDGs. More can be achieved for less cost—as will be revealed in the next chapter. In commercial organizations, the amount of capital available is limited, and any associated financing costs have to be recovered from the return on investments (ROI) made—through increased profits resulting from the possibility of better, more expansive, or more efficient service. Managers have clear incentives to use their limited capital resources wisely.

This commercial orientation can be compared to the situation facing planners and managers of water service providers in developing countries where a different set of rules and incentives prevail. For example:

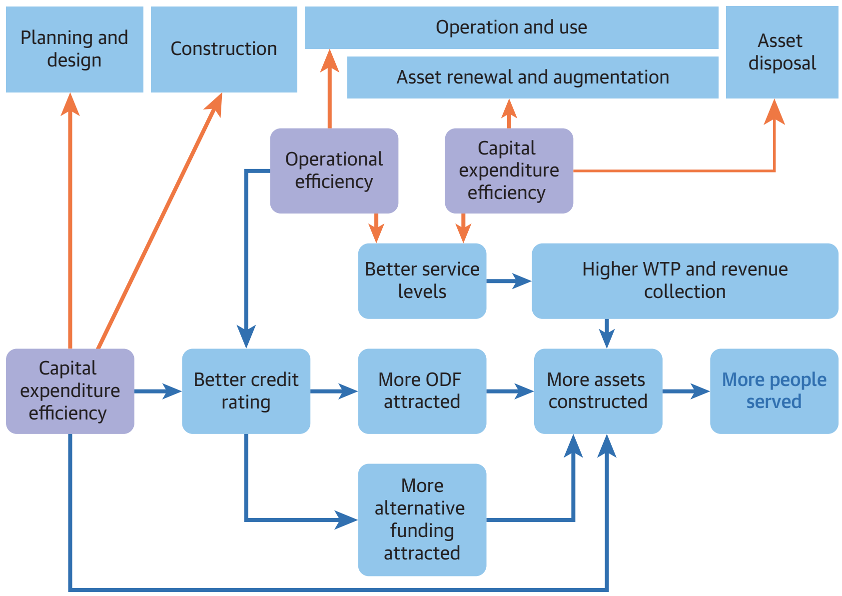
- Capital is rarely allocated based on a rigorous cost benefit analysis. Instead allocation is more likely to be driven by political or equity considerations.
- Capital is often provided free or at below market rates to the service providers. Thus the "cost of borrowing" is distorted and a utility is agnostic as to whether it spends $100m or $125m of Government sourced funding to provide the same level of improved coverage or service improvement. If utilities faced the full cost of capital funding, it is certain that greater attention would be paid to efficient use of that capital.[1]
- Utilities are natural monopolies *of piped water services*. They provide as much or as little service as they are able or willing to do. They are typically underfunded and reliant on unreliable subsidies from government - thus providing a ready excuse for their weak performance.
- Customers have little voice to influence the quality of service delivery and any service gaps are filled by self-provisioning or by private sector entities.

These weak or perverse incentives, coupled with lack of human capacity, mean that opportunities to maximize value from available capital are rarely exercised in the water sector. Yet there are significant opportunity costs associated with this inefficient use of funding—especially so, given the fact that this funding could have been utilized to provide WASH services to many other people currently without adequate access; and that official development finance (ODF) is finite.

Figure 2.3 and associated text below expands on how the efficient use of capital is a key ingredient in all phases of an asset life in expanding service coverage.

Activities leading to capital efficiencies during the design and construction phases will potentially free up resources to invest in extending services to unserviced areas, thus increasing its revenue base. This tends to improve the credit rating of the water utility, similar to the positive consequences of enhanced operational efficiency. Increased creditworthiness will in turn lead to attracting more ODF from international donor agencies in the short to medium term, government funding, and alternative forms of funding such as domestic commercial financing (Kolker and others 2016). Acquisition and optimal use of these funds will enable the water utility to further extend infrastructure services and provide services to larger populations. Improved efficiency will lead to improved service quality, which will in turn lead to higher willingness to pay (WTP) for the WASH services, as well as higher cost recovery (Kayaga, Franceys, and Sansom 2004). All of this leads to more infrastructure assets to extend services to the hitherto unserviced populations.

FIGURE 2.3. Capital Expenditure Efficiency Interventions in the WASH Service Life Cycle and Outcomes



Note: Orange arrows pertain to interventions related to capital expenditure efficiency (CEE) and operational efficiency (OE); blue arrows pertain to consequences of CEE and OE. ODF = official development finance; WASH = water supply, sanitation, and hygiene; WTP = willingness to pay.

As will be seen in the following chapter, CEE in delivering new water and sanitation assets involves selecting the most cost-effective investment approach toward a defined target, improving procurement efficiency, and optimizing how the project is delivered.

Note

1. For water utilities in England and Wales (United Kingdom), capital costs amount to an average of 49 percent of total costs based on author's compilation from annual performance reviews for 2016-17 for the 10 water and sewage companies and the five main water-only companies.

Chapter 3
Approaches to Improving Capital Expenditure Efficiency in the Water Sector

Improvement in capital expenditure efficiency (CEE) can be achieved in various ways. As highlighted in chapter 2, achieving CEE requires interventions in all phases of the water supply, sanitation, and hygiene (WASH) service chain. This chapter highlights a range of possible interventions. For clarity, they are presented in eight broad categories (sometimes overlapping and sometimes reinforcing) supported by example case studies. There are many other ways that these opportunities could be presented, but these could be further refined in future work on the topic.

- Strategic planning
- Technological innovation
- Use of simple, robust, and low-cost technology
- Optimized project design and management
- Efficient procurement
- Effective and efficient capital maintenance
- Incentive-based approaches toward capital expenditure efficiency
- End-use water demand management

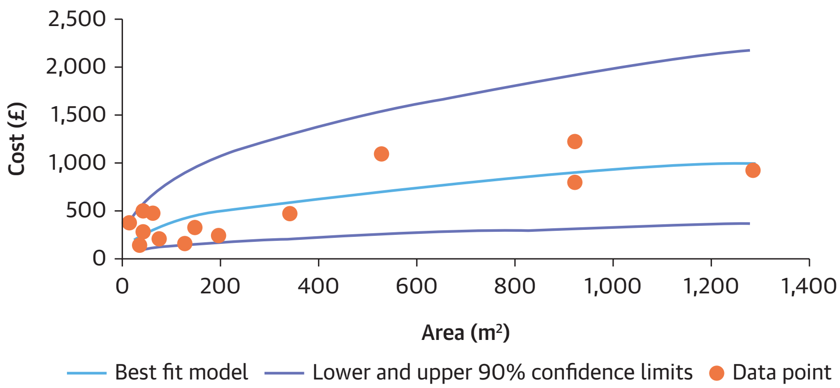
Strategic Planning

Strategic planning at the sector or service provider level requires consideration of many issues including, for example, target service levels, estimated capital and operating costs, funding sources (three T's—taxes, tariffs, and transfers), repayable financing arrangements, timing of investments, human capacity, construction industry competitiveness, and opportunities for efficiencies. A sound prioritization approach[1] will be critical given the multitude of conflicting opportunities to be considered.

This report does not consider this higher level of strategic planning in the allocation of funds but focuses instead on the fact that for CEE to take deep root, there is a need to mainstream the concept into the sector and its organizations' strategies, policies, and objectives. Focus on CEE should be highlighted in the sector's objectives, and any strategic planning process should include analysis of needs to achieve CEE. This means there should be adequate structures, systems, procedures, and mechanisms in place to enable the enhancement of CEE within the organization. For instance, the water utility should have regularly updated information on the state of the current asset base and knowledge on future demand for the WASH services; at the sector level, the cost of providing services should be routinely captured and analyzed. All approaches described in the following sections should be considered as integral parts of any sector or utility's planning process to decide the extent to which CEE can be captured to deliver maximum results for the least cost. Practitioners should be encouraged to seek out capital-efficient solutions and incentives provided accordingly.

Strategic planning may be supported by simple tools, such as the citywide inclusive sanitation (CWIS) tool,[2] which allows for different options to be modeled and compared against one another, or more advanced capital management tools. As an example of the latter, the asset strategy team of WRc,[3] a U.K. environmental consulting firm, has developed a medium- and long-term planning tool (TR61), which models a range of costs across water and wastewater assets. TR61 was first published in 1977, and the 13th edition, issued in October 2017, is a comprehensive software cost estimation tool. These models were developed from cost data obtained from construction and operation of water utility assets and infrastructure regularly provided to WRc over the past 40 years. Applications of TR61 include benchmarking capital costs against estimates

FIGURE 3.1. Example of a TR61 Cost Estimation Model



obtained from engineering contractors or their cost models; cost estimation for new schemes and asset valuation; supporting options appraisal in asset management planning; and gap-filling for missing or inadequate cost data. Figure 3.1 shows an example of a cost function generated by the TR61 models (WRc).

Strategic planning should also challenge traditional notions of meeting future needs. For example, there is increasing attention to the use of more decentralized systems of water supply and sanitation. Such models can provide greater flexibility in rapidly changing environments whilst avoiding large investments in extensive bulk, piped, infrastructure. Another example would be increased use of more sophisticated planning tools for decision making under uncertainty—especially important in systems that may be affected by climate change (World Bank, forthcoming).

Technological Innovation

Technological innovations comprise new products and processes and significant technological changes of existing products and processes (Organisation for Economic Co-operation and Development [OECD]). Given the massive amounts of resources required to meet the WASH SDG targets, it will be necessary to accept and adopt innovative approaches. Smart water, for example, promotes "the efficient use of water and energy, the reuse of water and wastewater treatment products (such as nutrients), and the smart, climate-proof design of sewerage and wastewater treatment systems, urban development plans and green and blue infrastructure for preventing urban flooding and reducing flood risks" (Ligtvoet and others 2014). Global Water Intelligence (GWI) noted that smart water approaches have the potential to reduce capital spending by 12 percent for water utilities in 2016-20 (2016). Thus, though many WASH sector policy makers and practitioners are traditionally risk-averse and cautious about innovation, meeting the SDG6 targets will require judicious adoption of more innovative approaches.

Urban sanitation, for example, should be high on the list of priority areas for CEE given that it is the single highest cost component in meeting the SDG6 and thus offers the potential for the highest absolute savings from application of CEE. One of the key technological innovations that could enhance CEE in the provision of off-site sanitation is the application of condominial systems where households are connected to the sewerage network through pipes that are shorter, shallower and smaller than those used in conventional sewerage systems. As a result, access to sewerage is provided at a significantly lower cost than when conventional sewerage is used. Savings noted in Africa, Asia, and South America are summarized in table 3.1, and case studies from Brazil are provided in boxes 3.1 and 3.2.

TABLE 3.1. The Cost of Condominial Sanitation and Savings Compared with Conventional Sewerage Systems

Project	Cost per dwelling (local currency and/ or US$ equivalent)	Capital spending saving compared with conventional sewerage	Source
South Africa – General (2002)	R 2,500–3,000 (US$290-348)	50%	Mpotulo 2002
Indonesia – SANIMAS (2003–09)	US$300	50%	Legowo 2010
Brazil – San Jose, Araguaína (2015)	BR 929 (US$268)	43%	Neder 2016
Brazil – Brasilia (1993–2001)	US$340	40%	Melo 2005
Brazil – San Jose, Bahia (1995–2000)	US$290	67%	Melo 2005
Sub-Saharan Africa (2008)	€200–400 (US$266-532)	50–60%	Monvois and others 2010

BOX 3.1. Condominial Sanitation in Brazil: An Evolutionary Approach in San Jose, Brazil

The Bahia state negotiated a $400 million funding package led by the World Bank for the development of comprehensive sewerage service in the state capital, San Jose. The original plan was to develop a sewerage network connecting 1.729 million people in 213,974 households, involving a total $186 million in investment for 1,177 km of sewers at a cost of $871 per household. At the start of the program, the condominial approach was used only where standard sewerage could not be used. Commencing 1994 it was used on a formal basis along with a program of public awareness building. From 1997 onwards following the success of its implementation, condominial sanitation was broadly adopted across the city. The condominial network costs $21 per meter against $52 per meter for conventional sewerage. The more condominial branches can be used, the lower the overall cost. 100-mm-diameter branch pipes were used for condominiums of as many as 20 households, 150-mm for 21 to 30 households, and 200-mm for more than 30 households. All network pipes are at least 150 mm.

Some 10,000 condominiums were created as points for community engagement and for each specific branch network. Although there was no connection charge, households were responsible for the internal works needed to replumb their latrines so that they drained into the condominial network. Where households chose to assume responsibility for the maintenance of the condominial branches, they received a 44 percent discount on the sewerage tariff. This has proved to be a popular option. As the networks were developed on a case-by-case basis in a city with many distinct geographies, overall numbers disguise appreciable variations at the condominial level. By 2000, 30 percent of households were connected to sewerage services.

Source: Melo 2005.

Condominials demonstrate the application of technological innovation as substitutes for existing technologies - replacing traditional sewer pipes with a condominial network. However, other innovations may provide completely new ways of tackling sector challenges and reduce capital costs. The so called “Internet of Things” (IOT)—the interconnection via the Internet of computing devices embedded in everyday objects, enabling them to send and receive data—may open many new opportunities for better management, monitoring, and control of WSS infrastructure. Although still in its infancy the IOT may lead to very different, and cost efficient, solutions compared to traditional approaches.

BOX 3.2. Condominial Sanitation in Brazil: A Systemic Approach in Brasilia

Unlike the city of San Jose described in box 3.1, Brasilia is a recently built city with a higher than usual degree of planning. Between 1993 and 2001, a comprehensive program was rolled out to extend sewerage on a purely condominial basis to 679,418 people in 4,977 condominiums in newly emerging satellite cities. 1,365 km of condominial branches were built along with 695 km of public networks, 625 km of which were built to condominial specifications. Condominial public network sewer pipes were buried at a depth of 0.5 to 1.2 meters against the standard norm of at least 1.0 to 1.3 meters, allowing inspection chambers to be installed every 24 meters instead of traditional manholes. These chambers are 10 percent of the cost of a manhole due to lower-cost materials and simpler construction. These condominial pipes cost $19 per meter; 13 percent for building inspection chambers, 19 percent for the pipe, and 68 percent for installation. For the branches, the minimum depth outside the plot is 0.6 meters and 0.3 meters within each household plot. There is a 40 percent tariff discount for self-maintenance.

Source: Melo 2005.

Use of Simple, Robust, and Low-Cost Technology

The level of technology needs to be matched with the existing social, cultural, and economic status of the beneficiary communities. In some cases, simple technological options are preferred to their more complex counterparts given that they are more robust, easy to operate, more cost-efficient, and they have a higher level of *maintainability*—that is "the ability of an item, under stated conditions of use, to be retained in or restored to a state in which it can perform its required functions, when maintenance is performed under stated conditions and using prescribed procedures and resources."[4]

For example, it was estimated that in the mid-2000s, 36 percent of 345,071 hand pumps in Sub-Saharan Africa covering 55.5 million people were non-functioning (RWSN, 2009) while the functionality of pumps installed in Liberia (n = 8,643), Sierra Leone (n = 22,809), Malawi (n = 26,070), and Tanzania (n = 22,761) declined to between 70 and 83 percent one year after construction and then to 12 to 59 percent after 25 years (Carter and Ross 2016). Addressing this issue is complex but includes procurement of pumps that are fit for purpose in their locality and that can be locally maintained. Although not independently verified, the potential benefits claimed in the use of such an approach could be significant—see box 3.3.

Nearly half of the world's population (48 percent) use on-site improved sanitation facilities (WHO/UNICEF 2017b). Many of these on-site sanitation facilities do not have good management systems to adequately handle the resulting accumulation of fecal sludge, mainly because engineers and planners perceive on-site sanitation to be a transitional service pending connection to sewerage systems (Strande, Ronteltap, and Brdjanovic 2014). Yet, as shown in box 3.4, fecal sludge management technologies are a robust, low-cost alternative technology to traditional solutions.

Optimized Project Design and Management

Good data and planning practices are a prerequisite for optimal project designs. Feasibility studies should be

BOX 3.3. Using Low-Cost Pumps Designed for Community Operation and Upkeep in Africa

Pump Aid (pumpaid.org) provides water to 500,000 people in Malawi through 4,000 Elephant Pumps. In total, 1.35 million people are served by 9,600 Elephant Pumps in Malawi, Zimbabwe, and Liberia. Hardware costs £900 with a total cost (including well digging, staff costs, local capacity building, and fuel) in Malawi of £3,070 per installation, or £25 per person. This is 60 percent less than conventional water pumps, plus the Elephant Pumps are designed to be significantly easier to maintain and have longer operational lives.

Only sites where groundwater recharge will at least match the overall rate of water withdrawal are used. Manufacturing of the concrete and metal parts is carried out as close to the site as is feasible. There is no branding on the hardware, as Pump Aid has found that people assume that branded hardware is owned by other people and thus they are not responsible for the pump's maintenance. The community is trained to operate and maintain each pump. A Water Point Committee is elected by the community to raise the funds needed for future maintenance and repairs. The pumps are designed so that they can be maintained using locally available materials with local labor through a network of artisans and welders. In Zimbabwe, it was found that 90 percent of pumps were still functioning seven years after Pump Aid left the country. There are also periodic site visits to check groundwater levels and quality, and procedures that can mobilize a repair team for major breakdowns such as a collapsed well.

Source: Pump Aid 2013.

BOX 3.4. Cutting Fecal Sludge Management Costs in Senegal

In Dakar, Senegal, a financial comparison was conducted between i) a sewer-based system with activated sludge and ii) a fecal sludge management (FSM) system with on-site septic tanks, collection and transport trucks, and drying beds. The annualized capital for the sewer-based system was US$42.66 per capita per year—10 times higher than the FSM system at US$4.05 per capita per year. The annual operating cost for the sewer-based system was US$11.98 per capita per year compared to that for the FSM system at US$7.58 per capita per year. The combined capital and operating for the sewer-based system was US$54.64 per capita per year—five times higher than that for the FSM system at US$11.63 per capita per year.

In Dakar, costs for the sewer-based system are almost entirely borne by the sanitation utility, with only 6 percent of the annualized cost borne by users of the system. In addition to costing less overall, the FSM system operates with a different business model, with costs spread among households, private companies, and the utility. Most of the costs pertaining to the FSM system are, for example, borne at the household level. Thus the sewer-based system was 40 times more expensive to implement for the utility than the FSM system. The results of the study illustrate that in low-income countries, vast improvements in sanitation can be affordable when employing FSM, whereas sewer-based systems are prohibitively expensive.

Source: Dodane and others 2012.

conducted to explore alternative choices, including assessing various factors related to sociocultural, technical/technological, economic, financial, institutional, and environmental aspects of the project area, as well as assessing sensitivity to different projections.

Project designs, and hence costs, are partly driven by application of design standards within a country. Sometimes these standards have been adopted from more advanced countries on the basis that they are what the host country should aspire to. There are costs in taking this approach—particularly in the sizing of assets as a result of unrealistically high per capita demand and/or population growth assumptions coupled with long design horizons. Assets developed on this basis are likely to be underutilized and may suffer further as a result of overoptimistic revenue assumptions, which are not achieved. The result is a curtailed economic life caused by lack of funds for proper operations and maintenance. Adopting realistic design criteria, considering how to make design horizons more reasonable, and building in modularity/staged construction to the design are all ways to improve the efficient use of capital.

Moving from top-down to bottom-up project design and management can also pay dividends. For WASH projects in developing countries, optimized project design and management may be achieved through the following actions:

- Engaging with all key stakeholders from the inception stage of the project, and, in some cases, investing in an appropriate level of capacity development of the beneficiaries
- Employing a bottom-up (demand-driven) rather than a top-down (supply-driven) approach, which enhances accountability and builds ownership by the beneficiary communities
- Building the project team's capabilities
- Developing the most suitable contracting and procurement strategies, taking into account the utilities' capabilities, supply chain options, and project risk

Decentralization of project management and delivery, along with using donated (free) labor offers the potential for significant cost savings, as illustrated in the following two case studies. However, it must be stressed that these alternative approaches to project development introduce new requirements for the project developer and, in particular, the need for comprehensive training and capacity building in the participating communities.

Box 3.5 illustrates how a WASH project in the Uttarakhand state in India mainstreamed decentralization in its design, leading to reduced project costs. It highlights that when beneficiary communities have been capacitated, decision-making and program supervision decentralized to the lowest levels could produce savings in capital expenditure.

Another example of how effective project design and management can enhance CEE is the renowned Orangi Pilot Project (OPP), a nongovernmental organization (NGO) project that has been active in Orangi, a low-income settlement in Karachi, since April 1980. OPP provides technical guidance, promotes community organization and self-management capabilities, and mobilizes community-based managerial and financial resources and guidance for providing robust and low-cost sanitation (Orangi Pilot Project Research and Training Institute 1995). Over the years, OPP has extended its scope in Orangi and the surrounding area to provide additional services including housing, health, microfinance, education, and rural development, and it has provided support to government and nongovernment agencies to scale up these services in other cities of Pakistan. Box 3.6 provides an overview of OPP and its impact in terms of CEE. Although not widely replicated, the OPP could be regarded as a benchmark for community-led sanitation initiatives.

Efficient Procurement

Procurement is the act of obtaining or buying goods and services. Inefficient procurement results in paying

BOX 3.5. Uttarakhand, India: Decentralized Service Delivery Model

The World Bank's International Development Association (IDA)-supported Uttarakhand Rural Water Supply and Sanitation services (URWSS) project was completed with significant savings on the original capital spending assumptions. It used a decentralization program to have all decision-making and work carried out at the lowest appropriate level. By 2015, 205,000 people in the villages had been trained to carry out the work and maintain the services. The project sought to provide safe household sanitation along with improved access to safe water supplies, which would be maintained during the dry season through catchment area conservation management schemes, where needed. Decentralization depends on capacity building down to the village level so that projects can be delivered and subsequently managed and supported by appropriate monitoring and reporting structures. Table B3.5.1 shows how decentralization contributed to lowering of project costs.

TABLE B3.5.1. Impact of Decentralization on Project Costs

	Project costs (Rs per household)			Saving over appraisal	Saving over GOI norm
	Government of India (GOI) norm	Appraisal estimates	Average project cost		
Single village	12,000	7,031	4,854	31.0%	60.0%
Multi village	25,000	10,320	7,972	22.8%	68.1%

Source: Mehta and Ancheta 2016.

BOX 3.6. The Orangi Pilot Project in Pakistan

The Orangi Pilot Project (OPP) was started by Dr. Akhtar Hameed Khan in 1980, leveraging his experience in developing businesses to support local self-help groups to provide a low-cost and self-sufficient method of delivering safe sanitation to the district.

Instead of regarding "poor communities as simply the objects of, rather than the central force of, development" (Zaidi 2001), the OPP has sought to base its work on the best use of available labor and materials to deliver access to safe sanitation. The OPP's "internal development" philosophy is somewhat controversial as it seeks to exclude all external sources of funding and assistance. Since 1988, low-cost sanitation projects have been managed by the Orangi Pilot Project-Research Training Institute (OPP-RTI).

Projects consist of two elements: The internal component covers lavatories and lanes. The lane connects the houses to a sewer. The external component is the trunk sewer connecting the lanes to bulk sewers and treatment plants. The projects are organized from the lane (20 to 40 households) upward, with the OPP providing technical information and lending equipment while encouraging each lane to deliver the actual work needed.

box continues next page

BOX 3.6. continued

The Orangi district is well-situated for a project of this nature. It forms a substantial and relatively contiguous urban area, which means that it benefits from economies of scale as the project expanded across the area and it is built upon a natural slope, obviating the need for some sewerage piping for connecting to the trunk sewer. As it is a well-established settlement, with many families living there for two or three generations, it has a settled and relatively skilled workforce. Also, having acknowledged owner occupiers makes community support easier to obtain as they have a personal stake in the project. Costs per household between 1991 and 2001 are summarized in table B3.6.1.

A rising cost per household over time is likely to reflect the impact of inflation. By 2016, 96 percent of households in the district had been connected to sanitation services.

TABLE B3.6.1. The Orangi Pilot Project Progress Summaries, from 1991–2016

Year	Households	Cost (Rs million)	Rs per household	Cost per household (US$)	Source
1991	68,794	51.27	745	7.08	Khan (1992)
1993	94,746	88.26	932	8.85	Ali (2004)
1999	90,596	78.79	870	8.26	WSP (2009
2001	92,184	82.14	891	8.47	Zaidi (2001)
2016	108,060	132.03	1,222	11.61	Saeed (2016)

Sources: Ali 2004; Bano 2008; Hasan 2003; Khan 1992; Saeed 2016; Zaidi 2001.

a higher price for the goods and services needed to deliver the appropriate level of service. Inefficient procurement may arise from the following situations:

- Small projects that cannot obtain best market prices for hardware through economies of scale
- Purchasing high-cost materials when cheaper options are available
- Overspecification of goods needed or inappropriate specifications
- Noncompetitive procurement, which limits the scope for lowering prices
- Lack of access to information for understanding which materials are the most appropriate
- Purchasing hardware on a piecemeal basis rather than in a lower-cost package

For rural households, the cost of purchasing a permanent latrine is a challenge given the complexity of the components needed and choice of materials. At the same time, small and sporadic ordering of sanitation materials makes economies of scale harder to achieve than for urban manufacturers. Box 3.7 describes a successful program in rural Vietnam that led to acceptance of alternative hardware materials, supported supply chain operators for toilets, delivered reduced capital costs, and increased sanitation access.

A similar approach was adopted in the province of Kandal, Cambodia, where purchasing and installing a latrine used to involve at least four separate calls, from ordering and purchasing hardware to having it installed. Instead, water and sanitation program (WSP)/iDE supported local entrepreneurs provide all

BOX 3.7. Vietnam: Prefabricated Rings for Cheaper Septic Tanks

The World Bank's water and sanitation program (WSP) implemented a three-year behavior change program in two provinces in Vietnam designed to assist in the adoption of hygienic latrines in rural areas starting in 2013. The program sought to educate rural communities about the benefits of safe sanitation and how to bring this about in the most affordable manner. Hòa Bình province is an upland part of North Vietnam with a population of 850,000.

The initial phase of the program focused on appreciating peoples' needs and concerns. Latrines were seen as desirable—but as a luxury rather than a necessity—demonstrating the need to explain the benefits of safe sanitation. Supply chain operators were incentivized to provide a one-stop-shop service, and households were advised that prefabricated concrete rings offer the same performance in septic tanks as concrete or red (clay) bricks. Using prefabricated well rings to make a septic tank lowers the cost of building a latrine in Vietnam from US$138 (D4.1 million using traditional red brick or D2.3 million using cement brick) to US$80 (D1.8 million). As shown in table B3.7.1 below, by using cement for the basement and walls, along with a tiled roof and concrete rings, the cost of a permanent latrine was D3.5 million instead of at least D5.3 million using traditional, high-cost components. In addition, the prefabricated units are appreciably easier to align, ensuring that the two tanks are effectively connected.

The project involved deploying more than 1,000 health staff and sale agents and 10 specialist sanitation entrepreneurs. During the 20-month period from mid-2013 to mid-2015, access to hygienic sanitation in the province rose from 27.7 to 48.4 percent against a national increase of 1.9 to 2.0 percent per annum. In addition, 71 percent of people surveyed in the area in 2015 stated that they planned to construct a latrine with 41 percent within the next year compared with a baseline of 7 percent. The chief concern remains affordability for poorer households; coverage rose from 18 to 24 percent for the poor against 34 to 60 percent for the non-poor.

TABLE B3.7.1. Sanitation Options for a Permanent Unit

Option	1	2	3
Superstructure	Cement walls	Cement walls	Cement walls
	No basement	Cement basement	Cement basement
	Tile or sheet roof	Tile or sheet roof	Cement roof
	Cost: US$40 (D1.2 million)	Cost: US$76 (D2.3 million)	Cost: US$93 (D2.8 million)
Septic tank	Concrete rings	Concrete brick	Red brick
	Cost: US$80 (D2.3 million)	Cost: US$102 (D3.0 million)	Cost: US$138 (D4.1 million)

Sources: Nguyen 2016; Nguyen and others 2016b.

the services through a single call. By using a standardized "easy latrine" design for a brick-walled pour-flush lavatory and improved delivery logistics, the cost of an installed latrine fell from $164 to $102 (CR 683,000 to 425,000) per household. The latrine unit now costs $40 to $55 per unit (CR 167,000 to 229,000), which is 20 to 30 percent less than one made by a local mason.

The introduction of e-procurement can also impact both the efficiency and effectiveness of procuring capital works. A study on procurement packages on public roads in Nepal (Iimi and Benamghar 2012) highlighted how the size of the public procurement package affected market competition and cost overruns, whereas others (Lewis-Faupel and others 2016) found that though e-procurement didn't reduce costs, it did facilitate the entry of higher-quality contractors, reduced delays, and improved quality of the works.

A key cause of inefficient procurement is corruption, which has been defined by the World Bank as the "abuse of public funds and/or office for private or political gain" (Halpern et al, 2008) Corruption and bribery divert funds from their intended use and drive up the price of equipment or accept poor-quality hardware at the expense of competitive procurement. Examples of effects of corruption are: (a) funds are diverted from their intended use; (b) cartels raise the price of materials; (c) bribes are taken to accept higher-cost goods; and (d) bribes are taken to purchase poor-quality goods. Given the high values involved, capital projects are the focus area for governments and other relevant stakeholder organizations to increase probity and improve governance.

Key actions that need to be undertaken to increase probity in the procurement of capital projects include: (a) establishment of sound planning and project evaluation procedures that help reduce opportunities for corruption; (b) having in place effective and standardized procurement rules and procedures; (c) effective procurement supervision; and (d) putting in place performance-based payments to increase probity in projects execution (Halpern et al 2008). Box 3.8 provides an example of good practice for monitoring probity in project procurement.

Effective and Efficient Capital Maintenance

Assets that are not properly maintained do not reach their full economic life and reduce CEE —requiring new assets to be built prematurely or curtailing the expected benefit stream from the asset. Maintainability of the assets needs to be considered from the inception phase through the project life cycle. Issues to be considered include robustness of the plant and equipment; efficient supply chain of spare parts; skills and competencies of the operation and maintenance staff; availability

BOX 3.8. Victoria, Australia: Rules for Project Procurement

The government of Victoria, Australia, has a clear probity policy that outlines procedures that must be followed by all government departments involved in procuring goods and services. Along with outlining anti-corruption principles to be incorporated in internal departmental processes, the probity policy provides for two key types of probity surveillance:

Probity Advisors – These advisors can be departmental staff or external consultants. They are generally individuals with experience and expertise in tendering and contracting and with good practical knowledge of probity issues. Probity advisors can play a key role in developing probity plans (required under the policy) and other procurement documents, and they may provide training for staff on probity principles and guidelines.

Probity Auditors – These are independent consultants with extensive experience in probity evaluation. They are generally hired for high-value transactions or for procurement where the services involved are complex or contentious or the nature of the market place makes bidder grievances more likely. The probity auditors can advise the government on probity-related issues during a tendering process, and they independently scrutinize (and report on) whether the tendering process adheres to the prescribed probity processes.

Source: Local Government Victoria 2013.

BOX 3.9. Ho Chi Minh City, Vietnam: Reducing Nonrevenue Water

In 2005, Vietnam's largest city, Ho Chi Minh City, did not have enough water supply to meet demand. More than 30 percent of the water produced was lost as leakage. Supply was intermittent. To increase supply to customers, the state-owned water utility, Saigon Water Corporation (SAWACO), competitively procured a contractor to enter a performance-based contract (PBC) for nonrevenue water (NRW) reduction with a focus on leakage reduction. For a different part of the network, SAWACO implemented a traditional project for leakage reduction, with remuneration based on inputs instead of outputs. SAWACO chose to implement both projects at the same time to learn the strengths and weaknesses of each approach. The results from the PBC are as follows:

- Savings of 122 million liters per day (MLD) of water after 6 years, which improved reliability of supply and allowed new customers to be connected
- Establishment of 119 district metered areas (DMAs)
- Savings of about US$100 million of capital expenditure on alternative water supply sources (using typical benchmark costs, a new supply of 122 MLD could have cost around US$120 million compared to the NRW-PBC cost of US$15 million)
- Repair of more than 15,000 leaks
- Reduced operating costs (energy and chemical costs) per unit of water sold because a higher percentage of water produced was sold
- Reduced leakage faster than the traditional project, which was developed at the same time as the PBC

Source: PPP Knowledge Lab, n.d.

of maintenance tools and equipment; setting up of effective maintenance management systems, including data collection and processing; performance management systems for maintenance activities, including monitoring and evaluation; research and development into innovative maintenance methods; and an overall enabling environment in the organization for effective maintenance management.

Water pipes make up the majority of asset value in a water supply system. The prevalence of high levels of physical leakage in the sector is an indicator of poor operation and maintenance of these pipes resulting from a long response time to repair leakages; no or poor active leak detection; no or poor pressure management of the distribution system; and no systematic methods of maintenance, replacement, and rehabilitation of the piped network components. As a result, the sector faces two challenges: addressing the backlog of leaks that have accumulated over time and maintaining low levels of leakage once the backlog has been fixed. An innovative performance-based contracting (PBC) model was used in Ho Chi Minh City, Vietnam, to tackle this issue (box 3.9) and which resulted in limited replacement of the pipe network thus making considerable capital savings. In addition the lower leakage levels meant that investments to expand production capacity could be reduced - another capital saving. Further examples are being developed as part of a World Bank initiative to reduce nonrevenue water (NRW) worldwide (Kingdom, 2006; 2018).

TABLE 3.2. **Comparison of NPV Depending on Achievement of Full Economic Life**

Approach to asset O&M	Discount rate	
	3%	6%
(a) Design, build, neglect, rebuild		
0–15 years (build)	1	1
15–30 years (rebuild)	0.642	0.417
Total NPV	**1.642**	**1.417**
(b) Design, build, maintain		
0–15 years (build)	1	1
15–30 years	0	0
Additional maintenance at 2% of capital cost per annum	0.39	0.28
Total NPV	**1.39**	**1.28**

Notes: Authors' computations assuming maintenance costs of 2% of capital expenditure. NPV = net present value; O&M = operations and maintenance.

More broadly, many development professionals are concerned about the lack of maintenance of new assets. Although the additional operations and maintenance (O&M) costs associated with new assets are incorporated into financial models at the project development stage, these costs are not necessarily budgeted once the assets are built. As a result, service deteriorates and the assets fail prematurely. The folly of this approach is illustrated in table 3.2, which compares NPVs (net present value) of two approaches to ensure an asset's notional full economic life of 30 years. In the first approach, design, build, neglect, rebuild is followed, and the asset achieves a life of only 15 years and has to be rebuilt at year 15. In the second approach, design, build, maintain is followed by providing adequate maintenance funds (assumed at 2 percent of capital costs per year) to ensure that the asset reaches its full economic life. Although simplistic, this model illustrates the point that design, build, maintain is a more cost-effective solution than design, build, neglect, rebuild.

Thus, improved operational management can have a direct impact on capital expenditure efficiency—that is, CEE is not just about initial capital expenditure (CAPEX) but is also dependent on good operations and maintenance.

Incentive-Based Approaches Toward Capital Expenditure Efficiency

The adoption of good CEE practices outlined in the previous sections will all help drive down capital costs. In this section, two approaches are presented where service providers and their contractors are provided with strong incentives to deliver the most efficient solutions.

Box 3.10 is a case study from the United States, where publicly owned water/wastewater utilities bundle and outsource some of their activities to third-party companies and, in the process, reduce CAPEX. It shows that in the United States, design-build (DB) and design-build-operate (DBO) contracts have potential to generate CAPEX savings compared to traditional design-bid-build (DBB) contracts. Although not specifically mentioned in the case study, such "bundled" approaches also often lead to faster implementation.

The World Bank Water Global Practice has developed a trial version of DBO procurement documents for water and wastewater treatment plant as a tool to help practitioners implement this model where clients have determined that it would be an appropriate contracting method (World Bank Group 2016).

BOX 3.10. U.S. Cost Savings through DB and DBO Contracts

Capital spending projects are usually carried out through the design-bid-build (DBB) process, where the utility designs and operates the new assets and invites companies to bid for the construction process. In design-build (DB) projects, the utility offers to both design and build the assets, thereby creating an environment for more innovative approaches. Design-build-operate (DBO) takes this a step further and adds operation of the new assets for a fixed period of time (Culp 2011).

Adams notes that the average capital savings for 19 water or wastewater DB projects in the United States was 39 percent over DBB projects; for 22 DBO contracts, the average life cycle cost savings was 26 percent (2003). Culp similarly noted that utilities have found that DB projects result in better-performing assets (2011).

Smith surveyed 32 public-private partnership DBO and related contracts in the United States where third-party data was available (2012). For the 28 contracts reviewed, water and wastewater projects handling 2.07 million M^3 of water and 4.51 million M^3 of wastewater a day resulted in capital savings of US$310 million for water (eight projects) and $891 million for wastewater (16 projects). This works out at US$149.8 per M^3 per day of treatment capacity for water and US$197.5 per M^3 for wastewater.

The second case described in box 3.11 is that of Ofwat, the water sector's statutory regulatory body for England and Wales that uses economic incentives to drive up CEE. As a result, water and sewerage companies have outperformed their efficiency targets in each successive asset management plan (AMP) cycle, translating into better service levels and lower tariffs for customers.

End-Use Water Demand Management

Water demand management (WDM) is the "development and implementation of strategies, policies, measures or other initiatives aimed at influencing demand, to achieve efficient and sustainable use of the scarce water resource." (Savenije and Van den Zaag, 2002) Implementing WDM measures, though an operational activity in nature, is an alternative to augmenting water infrastructure assets and, as a result, reduces the need for CAPEX investments by deferring them or even eliminating the need for them altogether. WDM also brings environmental benefits such as lower withdrawals from water sources, as well as reduction in chemicals and energy consumed for water treatment, transmission, and distribution.

WDM can be implemented at the utility level by improving operational and systems efficiencies in the water treatment plants, in the water distribution networks, or at the end-use level through the use of fixtures that use less water and/or users' behavior modification (Kayaga 2011). Water utilities need to actively promote end-use WDM through customer sensitization and provision of incentives for installation of water-saving fixtures and fittings. The utilities could also use the design of the water tariff as an economic instrument to encourage end-use WDM.

Boxes 3.12 and 3.13 shows examples of situations where deliberate measures undertaken by water utilities led to a reduction of water consumed by customers. Although not directly captured in the case studies, it is likely that implementing end-use WDM programs will contribute to CEE on a long-term basis.

BOX 3.11. Ofwat: Incentive-Based Economic Regulation in England and Wales

As part of the full privatization of the 10 English and Welsh water and sewerage companies (WaSCs) in 1989, Ofwat was appointed as an independent economic regulator for the sector. Economic regulation is carried out through price reviews (PRs), which set a company's price limit for each year during a five-year period. To date, there have been five PRs with the latest one (PR14) covering 2015–20. The pricing formula is designed to incentivize companies to perform strongly in terms of service delivery and environmental compliance, as well as to outperform their efficiency improvements during each five-year period.

In each PR, companies submit a business plan, making a case for their spending and future tariffs. Ofwat scrutinizes these and makes an interim determination and, following further representations, a final determination. The impact of these determinations can be significant. In every asset management plan (AMP) for the five-year period covered by each PR, companies have outperformed their efficiency targets. Companies are allowed to retain outperformance gained during each AMP, but each subsequent AMP is structured to reflect the gains made in the previous one. The impact of Ofwat's determinations on companies' business plans is summarized in table B3.11.1. This is a weighted average for the 10 WaSCs.

The fact that the companies have remained financially viable and have broadly met their service and environmental obligations suggests that incentive-based regulation has caused utilities to deliver capital spending obligations more cheaply and to optimize the cost of their capital. The narrowing of the differences between the business plans and the final determinations since 2000 suggests that there is a closer understanding between the companies and the regulator about efficiency targets and as inefficiency is driven out over time, opportunities for further efficiency are reduced.

The reduction in allowed capital spending in the final determination compared with the company business plans was 26 percent in PR99, 19 percent in PR04, 9 percent in PR09, and 1 percent in PR14 (PR14 is for combined operating and capital spending). Since 2010, Ofwat has favored innovative techniques in order to push efficiency forward. They have moved from separate CAPEX and OPEX targets to a combined TOTEX spending target to encourage companies to explore how CAPEX and OPEX work together increase efficiency—thus, companies are not constrained if spending more on OPEX improves CAPEX by a greater degree or higher CAPEX spending results in outperformance in OPEX.

TABLE B3.11.1. Difference between Ofwat's Final Determinations and Companies' Business Plans

Percent change per annum	1995–2000	2000–05	2005–10	2010–15	2015–20
Business plan	6.4%	5.9%	6.3%	2.4%	−0.4%
Final determinations	1.5%	−2.0%	4.3%	0.5%	−1.0%
Difference	−4.9%	−7.9%	−2.0%	−1.9%	−0.6%

Source: Ofwat 1994, 1999, 2009, 2014.

BOX 3.12. Copenhagen: Cutting Customer Consumption

Per capita consumption has fallen from 171 liters per day in 1987 to 135 in 1995, 108 in 2010, and 100 in 2015. In 2002, universal water metering was introduced (126 litres per capita per day (lpcd) at the time), followed by double-flush lavatories in 2005 (121 lpcd at the time) and rainwater reuse in 2008 (114 lpcd at the time). High water and wastewater tariffs and water resource taxes have been implemented to encourage demand management (Skytte 2016). Demand management is also implemented with leakage management where nonrevenue water (NRW) is 6 percent despite 76 percent of the city's pipes being more than 60 years old and the network having an ILI (infrastructure leakage index) of 2.5.

Sources: Skytte 2016; Pedersen and Klee 2013.

BOX 3.13. Economic Instruments for Water Demand Management in Zaragoza, Spain

At the end of the last century the municipality of Zaragoza in central Spain (population 682,300 in 2008) suffered a drought which ended in 1995. At that time the water tariffs set by Zaragoza City Council and its service provider (AYTO) were mainly driven by financial and political considerations rather than economic ones. AYTO initiated a long-term program to reform the tariffs in 1995, in which changes were implemented in a step-wise fashion with the aim of influencing water consumption. The reform process was informed by findings of an econometric study carried out by the University of Zaragoza.

The new tariff structure that became operational in 1995 was composed of service charge and variable volumetric charge components, which were designed to match the socioeconomic attributes and consumption habits of the population while achieving revenue sufficiency. Furthermore, AYTO offered economic incentives to households that reduced their consumption rates. For instance, if households reduced consumption by at least 40 percent in the first year of joining the plan they were entitled to a 10 percent discount on their bill. In subsequent years, they were expected to reduce consumption by 10 percent per annum in order to benefit from a similar price rebate.

As a result of these economic instruments, there was a 14 percent reduction in the city's water demand between 1996 and 2004, though the population increased by 6.3 percent in the same period.

Source: Kayaga and Smout 2011.

Notes

1. Readers may be interested in the World Bank report "Rethinking Infrastructure in Latin America and the Caribbean: Spending Better to Achieve More" (Fay and others 2017) available at http://documents.worldbank.org/curated/en/691941502376110277/Spending-better-to-achieve-morehttps://hubs.worldbank.org/docs/ImageBank/Pages/DocProfile.aspx?nodeid=27809478.
2. For further details, see the Citywide Inclusive Sanitation website at https://citywideinclusivesanitation.com/.
3. http://www.wrcplc.co.uk.
4. From http://web.utk.edu/~kkirby/IE591/ReliabEg_1.pdf, accessed on April 16, 2018.

Chapter 4
Conclusions and Suggestions for Ways Forward

Overview of Options for Capital Expenditure Efficiency

This report set out to illustrate how a sharper focus on capital expenditure efficiency (CEE) can help countries achieve Sustainable Development Goal (SDG) Targets 6.1 and 6.2 by reducing the financing gap identified in chapter 2. Whereas operational efficiency has always been prioritized by donor agencies, policy makers, and practitioners in the water supply, sanitation, and hygiene (WASH) sector, CEE is less visible given that the impact is "prospective" (that is, it delivers savings against an estimated future capital requirement) and that official development finance (ODF) is often considered "free" by its beneficiaries (so the consequences of inefficient use of capital are not obvious). Yet in a full cost analysis, the operating costs and the capital costs are almost equally important.

The main activities for enhancing CEE have been classified into eight broad (and sometimes overlapping) categories as shown in figure 4.1, which illustrates the funding gap as an octagon. Implementation of activities under each of the options would reduce the gap. The suite of options to be implemented would depend on the contextual factors of the environment in which the water utility is operating. It should, however, be noted that all these measures are components of an overall CEE strategy, which should be mainstreamed into the sector or the utility's corporate strategic plan. These components are described earlier in this report and summarized below.

Adopting CEE as part of utility or sector ***strategic planning*** provides a foundation for its widespread adoption in projects and may also introduce sector-wide changes through, for example, consideration of more decentralized approaches compared to traditional centralized models of service delivery. ***Technological innovations*** can contribute significantly to CEE. Documented examples include smart water approaches and innovative wastewater collection, treatment, and disposal technologies whilst the future may involve IOT as a way to further reduce capital expenditures. Overlapping with technological innovation is ***use of simple, robust, and low-cost technologies*** for provision of WASH services. Even where such technologies have been tried and found to be effective and efficient, some WASH professionals have preferred conventional and more complex technologies. There is need for a mind-set change in WASH professionals in favor of innovative, unconventional, but robust and cost-effective technologies.

The case studies illustrate substantial reductions in capital costs through ***optimized project design and management***, through adoption of bottom-up approaches that allow participation of the beneficiary communities and key stakeholders in the planning, design, and construction of the assets. This approach, and others, requires a professionalized and capacitated project management team that mainstreams this CEE strategy within the overall corporate strategy for WASH service expansion. One component of the optimized project design and management aspect is ***efficient procurement***, including e-procurement, which deserves further focus. There is a need to put in place systems and procedures for promoting probity in the procurement process and to maximize market efficiency in terms of purchase of goods and services and supply chains.

To maximize the operational life of the installed assets, there is need to put systems, mechanisms, and procedures required for ***effective and efficient capital maintenance***. Timely replacement and rehabilitation of the water distribution network and the water treatment plant/machinery is crucial for providing adequate levels of service to existing and new consumers. Improved asset operation and maintenance is a priority to avoid wasted capital as a result of a design, build, neglect, rebuild mentality.

FIGURE 4.1. Components of a Capital Expenditure Efficiency Strategy

Note: CAPEX = capital expenditure; CAPMANEX = capital maintenance expenditure; CE = capital efficiency.

At the national and corporate levels, policy makers could operationalize ***incentive-based approaches toward capital expenditure efficiency*** as a measure for enhancing efficiency gains. Incentives for increasing CEE could be incorporated into the regulatory mechanisms and structures, as is the case of the United Kingdom's Ofwat's price cap regulation, or at the utility corporate level, as is the case of several the United States's water utilities that achieve cost savings through design-build-operate (DBO) contracts.

A longer-term measure for reducing funding gaps is ***end-use water demand management*** (WDM), which involves modifying the behaviors of customers so that they use water services more efficiently. By lowering water consumption, this measure optimizes existing resources and assets, hence postponing or eliminating the need for new ones.

The report does not attempt to put a figure on the savings that could be achieved through greater attention to CEE during the SDG period. A comprehensive analysis of SDG investment categories linked to potential capital savings would be needed, and this is outside the scope of the study. However, almost all of the examples presented in this report show capital savings in the order of 25 percent or more compared to traditional solutions. This alone should give policy makers, donors, and utility managers pause for thought and encourage them to seek ways to develop CEE in their sectors, projects, or utilities.

Nor does the report try to uncover the root cause of non-application of CEE in development. This might be ignorance about possible solutions, inertia, lack of incentives, or weak capacity. Whatever the cause, further analysis is needed to understand what actions would be needed to see more widespread use of CEE.

Suggested Next Steps

As laid out in the report's Introduction, the purpose of this work was not to undertake a deep and comprehensive analysis of CEE in the water and sanitation sector but to compile practical examples that highlight the potential for greater CEE in the sector and the opportunities that flow from those. These include improving the efficiency and effectiveness of existing (substantial) investments that governments and donors make in the water and sanitation sector and reducing the investment financing gap to achieve the SDGs.

Put simply, this work provides a "taster" on CEE and its importance in the sector.

As a result, no firm set of recommendations are provided[1] except to exhort practitioners to be more active in considering opportunities for CEE in their policies, sector investment plans, and project designs.

However, the examples presented here should be sufficient to encourage the deeper and more comprehensive analysis mentioned above. This might cover a broad range of issues including the following:

- Clarification of the role of CEE in sector strategic planning—including capital allocation and prioritization
- Creation of a more nuanced analysis of the relative importance of capital versus operating costs at the sector and subsector levels
- Determination of the potential cost reductions in meeting the SDGs when CEE is more widely applied
- Determination of the increased benefits that would flow from applying CEE to current investments undertaken by governments and donors
- A more extensive set of case studies to broaden and deepen examples of approaches that have been adopted to deliver improved CEE
- A root-cause analysis looking at capacity, governance, and incentives to better understand the obstacles to widespread adoption of the CEE approach
- Proposition of different approaches by which CEE could be actively introduced to government and donor policies—including through line ministries, finance ministries, regulators, local governments, and service providers
- Development of incentive models that will encourage adoption of those policies by practitioners
- Consideration of more systematic data collection on capital costs for the sector, which would provide practitioners with better benchmarks when assessing the costs of proposed capital solutions

Note

1. Interim suggestions are, however, provided in appendix A pending a more comprehensive analysis.

Appendix A
Categories of Actions for Enhancing Capital Efficiency—Interim Suggestions

Category of capital expenditure efficiency (CEE) actions and brief narrative	Key suggestions	Government	Service provider	Donor
1. Strategic orientation and planning—Focus on capital efficiency should be highlighted in all sector and organizational objectives	• Actively engage with policy makers and practitioners to change mindsets about the opportunities for CEE and the true costs of official development finance (ODF).	√	√	√
	• Adopt planning approaches that actively consider opportunities to capture capital expenditure efficiencies (CEE) and promote benchmarking of capital costs.	√	√	
2. Technological innovations take place when new products and processes are developed and/or significant technological changes of products and processes take place	• Give relevant staff incentives for innovation, and reduce their risk-aversion, through capacity development.	√	√	√
	• At the planning stage, evaluate, where applicable, proven but nonconventional technologies.		√	√
3. Use of simple, robust, and low-cost technology—Simple technological options exist that are robust, easy to operate, and more cost-efficient and that have a higher level of maintainability	• At the planning stage, evaluate, where applicable, options for simple technological solutions that have proved to have acceptable levels of performance and maintainability.		√	√
4. Incentive-based approaches toward capital efficiency—Incentives could be incorporated into the regulatory mechanisms and structures or at the utility level	• At the sectorwide level, incorporate into the government financing strategy (or regulatory regime) standards and metrics that encourage service providers to prioritize CEE.	√		
	• At the water utility level, in the planning stage, evaluate, where applicable, opportunities for innovative project structuring that leads to CEE gains.		√	√
5. Optimized project design and management will not only enhance capital efficiency but also bring the assets online sooner, hence improving the net benefits to the citizens	• Build the project team's capabilities in project design and management skills, which will enable them to develop/strengthen CEE aspects of infrastructure development.	√	√	
	• Revisit design standards and target levels of service to be more appropriate for the country context.	√		
	• Where appropriate, adopt bottom-up approaches, which engenders participation and ownership of the beneficiary communities and other relevant stakeholders.	√	√	√
6. Efficient procurement maximizes market efficiency in purchase of goods and services and requires systems and procedures for promoting probity in the procurement process	• Promote market development to deliver appropriate, cost-effective, and integrated solutions.	√	√	
	• Establish systems, structures, procedures, and mechanisms for enforcing and monitoring probity in the procurement of capital projects.	√	√	√

table continues next page

Category of capital expenditure efficiency (CEE) actions and brief narrative	Key suggestions	Government	Service provider	Donor
7. Effective and efficient capital maintenance management—Improved asset operation and maintenance is a priority to avoid wasted capital as a result of a design, build, neglect, rebuild mentality	• Establish adequate operations and maintenance (O&M) resources and robust maintenance management systems, structures, procedures, and mechanisms to maximize the operational life of the water supply, sanitation, and hygiene (WASH) assets.		√	√
8. End-use water demand management (WDM) modifies behaviors of customers so that they use water services more efficiently and thus defer or eliminate need for capital	• Design tariff structures that encourage efficient use of water in customer's premises.	√	√	
	• Promote end-use WDM through engagement, education, and economic instruments to reduce, defer, or eliminate investments.		√	√

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