Cash Flow Equilibrium Model for Water Utilities
CFEM Version 1.01

User Manual
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I. The Basics

I.1. Model purpose and development

This user manual describes a Cash Flow Equilibrium Model (CFEM) for Water Utilities that was originally developed for the World Bank in the mid-1990s for the evaluation of a municipal water supply project in Senegal. The standard World Bank procedure for analyzing a water supply augmentation project is to conduct two separate studies: (1) an analysis of the water sector, and (2) a financial analysis of the investment project itself. For the case of this water project in Senegal, task manager Dr. Jan Janssens and financial analyst Mr. Claude Sorel proposed linking these two efforts in order to study the investment project as an integral part of the water sector. They engaged Ernst and Young, Inc. to create an integrated sector financial model.

The result of the collaboration between Ernst and Young and Dr. Janssens and Mr. Sorel was the Cash Flow Equilibrium Model. The CFEM calculates the cash flow position of the water sector over 20 years, with and without the proposed investment project. This model predicts the increase in the average tariff that will be necessary to bring the water sector into financial equilibrium by a given year (specified by the model user). The model runs in Microsoft Excel and solves for the necessary annual percent increase in the average tariff using Excel’s “Goal Seek” function.

Dr. Janssens used this model to conduct project appraisals in Senegal on two occasions. The CFEM has also been applied to the analysis of water sector investment projects in Niger and Burkina Faso. In each of these applications the original model was adapted to …

(i) the institutional structure of the sector,
(ii) the financial situation of the utility,
(iii) the proposed investment options, and
(iv) the proposed financing of these investments and of the temporary operating deficits prior to achieving financial equilibrium.

The Cash Flow Equilibrium Model addresses different questions than the classical project appraisal calculation of the internal rate of return of an investment project. The Cash Flow Equilibrium Model can be used to explore the interrelationship between new investments, tariff levels, and operating deficits. The model shows how large the operating deficit will be given a particular tariff level, or how much the tariff must increase to eliminate the operating deficit. In the case of Senegal, the model was used to predict the per cubic meter price that a potential private operator would bid in his proposal for a lease contract.

Despite its flexibility, the Cash Flow Equilibrium Model that was used in West Africa (Senegal, Niger, and Burkina Faso) has several limitations that restricted its application to other countries and to broader policy questions. One fundamental problem for some users was that the model was written in French and had no user manual. Another difficulty was that the existing examples of the model were all case specific, making it hard for the first-time user to
understand the fundamental structure of the model and how it had been adapted to the specifics of each case.

More importantly, the model as applied in Africa could not accommodate differential tariff increases across customer classes. How the required increase in average tariff level is distributed across groups is, however, often a critical question for policy makers. The CFEM could not help policy makers address this question because it assumed that the tariff increase for each customer class would be the same. Finally, the simple user interface in the early versions of the model was not suitable for use in policy briefings or for use by those who do not understand the intricacies of Excel.

In spring 2001, the World Bank contracted with a team from the University of North Carolina at Chapel Hill to address these limitations with the existing model.\(^1\) Dr. Jan Janssens supervised this effort, and Mr. Claude Sorel provided technical guidance. This user manual and the accompanying Version 1.01 of the Cash Flow Equilibrium Model for Water Utilities is the result of this collaboration. This version of the model is written in English and runs in Excel.

\(^{1}\) The UNC-CH team consisted of Kristin Komives, Prabhu Vimalanand, and Dale Whittington.
I.2. Model structure

The Cash Flow Equilibrium Model examines the effect of policy variables, such as (a) new investments and (b) the time permitted before reaching financial equilibrium, on the financial health of the water sector (see Text Box 1). It is assumed that the sector is in financial disequilibrium in the initial period, and that tariffs are too low to generate sufficient revenues to cover the sector's costs. The model is designed to answer is the following policy question: "What percentage increase in average water tariffs will be needed each year to achieve financial equilibrium in the water sector in a user-specified future period, given future investment plans in the sector?"

At the heart of the model is the balance sheet – a statement of the financial position of the water utility at the end of each year. The balance sheets are linked from year to year through three statements of change in financial position: (1) the income statement, (2) the flow-of-funds statement, and (3) the statement of change in working capital needs. The water utility is defined as reaching financial equilibrium when the cash position on the balance sheet equals zero.

Historical data are used to create the balance sheet, income statement, flow-of-funds statement, and working capital statement for the water sector in the first year of the model simulation. Cost and feasibility studies are used to enter information about potential new investment plans.

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Text Box 1: Defining the water sector

CFEM Version 1.01 is designed for application to a general municipal water situation in which the cash flow position of the water sector is equated with the cash flow position of the public water utility. In other words, when the public water utility reaches financial equilibrium, so does the water sector.

The model does allow for the public water utility to contract with a private operator for the operation of the water system. This private operator is compensated on a per cubic meter basis (at a price specified by the CFEM user that is assumed to be high enough to cover the costs and reasonable profit of the private operator). From the perspective of the water utility, this payment to the private operator is simply a variable cost of operation. This structure resembles a short-term management contract with no built-in efficiency incentives or penalties for the private contractor for non-attainment of objectives.

Keeping the model structure simple makes it easier for users to understand how the model works and what assumptions underlie the model results. However, the basic institutional structure of CFEM Version 1.01 will be too simple for many cases to which the model will be applied. The user can adapt the model to include additional institutions, such as a bulk water providers and regulators. A user can also adapt the model to more complex contract structures.

At the heart of the model is the balance sheet – a statement of the financial position of the water utility at the end of each year. The balance sheets are linked from year to year through three statements of change in financial position: (1) the income statement, (2) the flow-of-funds statement, and (3) the statement of change in working capital needs. The water utility is defined as reaching financial equilibrium when the cash position on the balance sheet equals zero.
projects (see Text Box 2). The model then calculates the balance sheet, income statement, flow-of-funds statement, and statement of working capital needs for the next 20 years given the infrastructure investment projects planned and the number of years permitted to reach financial equilibrium.

Text Box 2: Infrastructure Investment Scenarios

The CFEM allows the users to choose to run financial simulations under four different infrastructure investment scenarios: the baseline infrastructure scenario, Project 1 scenario, Project 2 scenario, and Project 1 + 2 scenario.

The first scenario is the **baseline infrastructure scenario**. In this scenario, the utility completes any capital investment projects that are currently underway and expands its system to be able to serve a defined number of new residential customers each year. The user can easily change the system expansion rate in the baseline infrastructure scenario on the first page of the user interface.

In the second infrastructure investment scenario, one new investment project is undertaken (**Project 1**) in addition to any ongoing investments in the baseline infrastructure scenario (Project 1 scenario = baseline infrastructure + Project 1). Project 1 may involve any type of work: expansion of water production capacity, improvements in the quality of service, reduction in water leakage, and/or expansion of the service area. The cost and production schedule of Project 1 must be defined in the Excel spreadsheet. The user can easily manipulate the financing arrangements for the project in the user interface.

The third infrastructure investment scenario also involves a new investment project: **Project 2**. Project 2 is distinct from Project 1, and, like Project 1, is undertaken in addition to any ongoing investments in the baseline infrastructure scenario (Project 2 scenario = baseline infrastructure + Project 2). The costs, production schedule, and financing arrangements for Project 2 are defined by the user in the Excel spreadsheet and through the user interface.

The final infrastructure scenario involves the implementation of both **Projects 1 and 2**. If this scenario is chosen, the model assumes that both project 1 and project 2 will be completed according to the time frame established for each. In addition, regular investments in the baseline infrastructure scenario will continue (Projects 1 + 2 scenario = Project 1 + Project 2 + baseline infrastructure).
After financial equilibrium is reached in the year specified by the user, the model ensures that the utility stays in financial equilibrium for the remainder of the planning period. The financial results generated by the model are based on projections of water consumption, available production capacity, operating costs, investment decisions, as well as other assumptions described in this user manual.

To run the model for a particular infrastructure investment scenario, the user chooses the future year in which the water utility must reach financial equilibrium and decides which capital investments will be made in the future. (The user also has the opportunity to change a number of other key assumptions that affect the financial results.) The model then solves for the annual percent increase in the average tariff that is needed each year in order to achieve financial equilibrium in the user-defined year. Based on this annual percent increase, the model produces 20 years of balance sheets and other financial results for the water utility. Excel solves for the annual percent increase in average tariff using the “goal seek” function. This function is a simple optimization routine based on interpolation; it can be used when the desired result of a single formula is known (in this case, the cash position of the utility’s balance sheet in the user-chosen year of financial equilibrium must equal 0), but the value of a single variable in the formula is not (in this case, the annual percent increase in average tariff). When “goal seeking”, Excel varies the annual percent increase in average tariff until the cash position in the utility’s balance sheet equals 0 in the user-chosen year of financial equilibrium.

The links between average tariff level, the annual percent increase, and the cash position on the balance sheet are depicted graphically in Figure 1 for the case where there is only one customer class. The tariff level affects water revenues (revenues = average tariff * cubic meters of water sold), which in turn determine the utility’s annual profit or loss on the income statement. Annual profit or loss then feeds into the balance sheet. The exact formulas behind these calculations are presented in section 2 of this user manual. Section 1.3 of the user manual explains how the goal seek function changes when there is more than one customer class.

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2 After reaching equilibrium, the model assumes that tariffs will increase annually at a constant rate defined by the user (e.g. inflation rate). As long as the user chooses a positive rate of increase in the tariffs and/or the service area of the utility continues to expand, the utility will continue to increase the cash position on the balance sheet in each year after reaching financial equilibrium. Problems with this result are discussed in section 1.6 below.
Figure 1:
Solving for the annual **% increase** in average tariff using the goal seek function in Excel (case of 1 customer class)
I. 3. New features in version 1.01 of the Cash Flow Equilibrium Model

In addition to its translation from French to English, Version 1.01 of the Cash Flow Equilibrium Model includes three major enhancements over previous versions of the model.

First, version 1.01 includes an improved user interface (See Figure 2) This interface makes the model suitable for use in policy briefings and helps make the assumptions behind the model clearer to both potential users and policy makers. Through the user interface, the model user can change key assumptions behind the model, run the model, and watch how changing the assumptions affects the financial results. [This user manual is also available to the user through the user interface.]

Second, the model now allows for multiple customer classes. The user can define the customer classes and also how tariff increases and any water shortages will be distributed across classes. Previous versions of the model either included only one customer class or required that the annual percentage increase in the average tariff level be the same across all customer classes.
CFEM Version 1.01 contains default residential and non-residential customer classes, and defines default per capita water use levels for each of the residential customer classes (See Figure 3). The user can choose to accept these assumptions or make modifications to the customer classes and/or per capita water use levels as appropriate.

Finally, The CFEM allows the user to choose from four different tariff increase formulas. The first formula is the one described in Figure 1 above: a uniform rate of increase in the average tariff that is the same across all customer classes until financial equilibrium is reached. For example, the average tariff for each customer class might increase by 5 percent per year until equilibrium. The model also includes three advanced tariff increase formulas, which introduce the possibility of varying rates of increase across customer classes and of manually defining the average tariff at some point in the future before financial equilibrium.

In the user interface, the first advanced tariff increase formula is called “rate of change differs across classes, no defined tariff”. With this formula, the increase in the average tariff remains constant across time (i.e. the rate of increase is the same every year), but the rate of increase varies across customer classes. The rate of change for each customer group is specified relative to the rate of change in the first residential customer group. In the example presented in Figure
4, Excel’s goal seek function would solve for the annual percent increase in the average tariff of customers with private metered connections (% increase customer group 1). The percent annual increase in the average tariff of customers with private unmetered connections would be 1.1 times the % increase customer group 1. The average tariff for customers using utility tanker trucks would not go up at all over time.

Figure 4:
Example of first advanced tariff increase formula:
Rate of change differs across classes, no defined tariff

In each of these first two tariff formulas, the annual percent increase in the average tariff is applied to the tariff in every year after the base year and up until the utility reaches financial equilibrium. By contrast, the last two tariff formulas allow the user to define a tariff for each customer group at one point in time before the utility reaches financial equilibrium. For example, the user could manually set the average tariff for each customer group in 2002 and then allow goal seek to solve for the percent annual increase in average tariff that would be needed in all years after 2002 in order to reach equilibrium by a particular year. The ability to define the average tariff at some point in the future is particularly useful when policymakers have already committed to a future tariff level, or want to time a specific tariff increases to coincide with the completion of service improvement works.
Figure 5 shows an example of the tariff formula “rate of change differs across classes, define tariff at one point in time”. This is the most complex tariff increase formula. In the example in Figure 6, the user has defined a tariff for each customer class in the year 2002. In every year from the base year until 2002, the tariff for each customer group will increase by 1% or 0%. The goal seek function will solve for the percent annual increase in the tariff for households with private metered connections in all years after 2002 and until financial equilibrium. The percent annual increases for other customer groups from 2002 until equilibrium will then be calculated based on this rate of increase.

The fourth and final tariff formula in the CFEM is “rate of change constant across classes, define tariff at one point in time.” With this formula, the user must specify tariffs at one point in the future before financial equilibrium. The goal seek function then solves for the rate of increase in average tariff for all customer groups until the utility reaches financial equilibrium.

(See appendix 2 for a more formal presentation of the tariff increase formulas.)
1.4 Key user-defined assumptions

The CFEM Version 1.01 does not predict the behavior of consumers or of the water utility. Rather the model’s financial results are based on the cost estimates (e.g. cost and financial of new investment) and behavioral predictions entered by the model user (e.g. water consumption, system expansion, technical efficiency, etc.) A number of the most important assumptions can be easily seen and modified by the user in the user interface. (Others can be altered only by entering the Excel spreadsheet that lies behind the user interface). This section of the user manual describes a number of these key assumptions.

Adjusted and unadjusted water use

The CFEM contains two types of water use projections – estimates of “unadjusted” and “adjusted” water use. “Unadjusted” consumption projections are built up from the user’s projections of the pace of system expansion, per capita water consumption by residential customers, the distribution of residential customers across customer classes, and annual growth in water use by non-residential customers. All of the assumptions can be easily changed in the user interface. “Unadjusted” consumption projections are made independently of the quantity of water available in the system for sale. In other words, the sum of the unadjusted consumption projections for each customer class could exceed the total amount of water available for sale.

“Adjusted” consumption projections are adjusted for the total amount of water available for sale. The model user is asked to decide how the water shortage will be spread across customer classes in the case of a water shortage. The entire shortage can be allocated to one customer group (i.e. water consumption for that customer group will be the unadjusted consumption minus the total amount of the shortage), or the deficit may be shared across classes.

Model users must first build unadjusted consumption projections and then decide how to allocate water shortages across groups if water use exceeds available water. The user can do most of this in the user interface, making it easy to change assumptions about water use projections during a policy briefing. The process of building water use projections is as follows. (A more formal presentation of this process is included in Appendix 3).

1. Define the number of residential utility customers

The first step in building total water use projections is to decide how many customers the utility has in the base year and how that number is likely to change over time. On page 2 of the user interface, the user is asked to enter the population of the city (or other relevant service area) in the base year. The user also defines the growth rate of this population over time and the percentage of the total population that is served by the utility in the base year.\(^3\)

\(^3\) The user has the ability to modify the number of new utility customers added each year in the baseline infrastructure scenario. But it is important to remember that the pace of service expansion should be consistent with the dollar amount invested in service expansion in the baseline infrastructure investment scenario.
In the example depicted in Figure 6, the population of the city in the year 2000 is 2,000,000, and is increasing at a rate of 5% per year. Only 50% of the population – or 1,000,000 people -- is served by the utility in 2000. If the utility follows the baseline infrastructure investment scenario (see Text Box 2), an additional 500 people will be served by the utility each year. In 2001, 1,000,500 people ( =1,000,000 + 500) out of a total population of 2,100,000 (=2,000,000 times 1.05) will be served by the utility. This is equivalent to a 48 percent coverage rate in 2001.

Figure 6:
Page two of the user interface

2. Define customer classes and per capita water use

On the next page of the user interface, the user is asked to make choices about customer classes and per capita water use assumptions for the residential customer classes. One option is to simply accept the default customer classes and water use assumptions that are shown above in Figure 3. Alternatively, the user may choose to insert his or her own water use assumptions and/or customer classes.

In the example shown in Figure 7, the user has opted to “define both customer classes and water use”. Choosing this option makes the boxes in the table turn light blue. The light blue color
indicates something that can be changed by the user. In this case, the user has eliminated all but five residential customer classes and has increased per capita water use. The user made no changes to the nonresidential customer classes. (Note: the final user group – other residential – is a required category.)

Figure 7:
Page 3 of the user interface: customer classes and water use

The next step is to decide how the residential customers are distributed across the five residential customer classes in the base year. In this example, we know that 1,000,000 customers are served by the utility in the base year. How many have private metered connections? Private unmetered?

On page 4 of the user manual, the user is asked to define what percentage of the utility’s residential customers are in each customer class. If 500,000 customers obtain water from private metered connections, then the user would record that 50% of all customers are in the private metered connection customer class. The example in figure 8 assigns an additional 250,000 (or 25%) customers to private non-metered connections. The remainder of the customers are split evenly between standposts and utility tanker trucks.
With this information, Excel calculates unadjusted water use by residential customers in the base year. If RESCUST$_{0j}$ is the number of customers in residential customer group $k$ (private metered connections, for example) in year 0 and PCWATER$_k$ is the average daily per capita water use for customers in group $k$, then the total *daily* water use by customer class $k$ in the base year equals RESCUST$_{0j}$ times PCWATER$_k$.$^4$

In this example, there are 500,000 customers using private metered connections, and each uses on average 120 liters per capita per day. Daily water consumption for this residential customer class equals 60 million liters. Total water use by customers with private metered connections in the base year would then be 365 times 60 million liters.

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$^4$ CFEM assumes that water use in each customer group will remain constant over time. After running the model, the user has an opportunity to change this assumption and examine how the financial results would change if water use changed over time. This option is described in more detail in section 1.6 below.
The same calculation is done for each residential customer group. Total unadjusted residential water consumption in the base year is the sum of water use in the base year for each customer group.

Residential water use in all years after the base year is calculated in the same way. Total unadjusted residential water use will change over time as the number of customers increases or decreases. These changes in the number of residential customers happen as a result of the regular service expansion that forms part of the baseline infrastructure scenario (e.g. Figure 6). In addition, the infrastructure investment projects 1 and 2 could also have an effect on the number of customers in a particular residential group. For example, if project 1 involved extending private connection service into a neighborhood with standposts, then the number of private connection customers would increase and the number of standpost customers would decrease as a result of the project. These project-related changes in the utility’s customer base cannot be manipulated through the user interface, but can be recorded in the details about the infrastructure investment projects on the Excel spreadsheet.

3. Define nonresidential water use

Nonresidential water use projections in this model are simpler than the residential water use projections. On page 4 of the user interface (see Figure 8), the user is asked to enter total water use by the nonresidential customer classes in the base year (in millions of liters per day). In the example in Figure 8, industry is using 40 million liters of water per day in the base year. Industrial use in the base year would be 40 million liters times 365.

The user also decides how rapidly water use by these nonresidential groups will increase or decrease over time. In this case, the user has chosen to assume that water use by all nonresidential customer groups will increase at a rate of 2% per year. Industrial water use one year after the base year will have increased to 40.8 million liters of water per day.

The unadjusted projection of total water use in a given year is simply the sum of the projections of water use for each residential and nonresidential customer class in that year.

4. Decide how to allocate water deficits across customer classes

The problem with these unadjusted projections arises when total predicted water use exceeds the total amount of water available for sale. In previous versions of CFEM, water use by all but one customer class was fixed, and the entire water deficit was “allocated” to one customer class. In other words, the water deficit was subtracted from the water use projections for that customer class.

CFEM Version 1.01 gives the user more flexibility. On page 9 of the user interface, the user can decide to allocate the water deficit only to one customer class, or can spread the deficit equally across all customer classes.
Assume for example that there were just two residential customer classes (private metered connections and standposts) and two nonresidential classes (industry and government). Each class was projected to use 50 million cubic meters of water per year in the year following the base year. But, due to water treatment constraints, only 160 million cubic meters of water would be available for consumption that year. The model user could choose to allocate the full deficit of 40 million cubic meters (200 million minus 160 million) to the industrial customer class. In this case, water use by each customer group would be the following:

- Private metered: 50 million cubic meters
- Standposts: 50 million cubic meters
- Industry: 10 million cubic meters
- Government: 50 million cubic meters.

Alternatively, the user could choose to spread the rationing equally across all groups – each class would consume 10 million cubic meters less per year. Water use by each group would then be as follows:

- Private metered: 40 million cubic meters
- Standposts: 40 million cubic meters
- Industry: 40 million cubic meters
- Government: 40 million cubic meters.

These water use projections are referred to in the CFEM Version 1.01 as “adjusted” water use projections. Utility revenue projections are based on adjusted water use projections.

Costs

The projections of operating costs in the CFEM have three components: fixed operating costs, fixed personnel costs, and variable costs. Costs in the base year are drawn from the utility’s financial data. The user then defines how these costs will change over time. The user interface offers the user three options about how these costs will change over time: (1) costs increase with inflation, (2) costs are constant over time (do not increase), or (3) costs increase at a user-defined rate different from inflation. In the example in Figure 9, the user defined the rate of increase for fixed operating costs, set personnel costs to remain constant over time, and let variable costs increase with inflation.
Variable costs in the CFEM model are per unit costs that can be associated either with payment to a private operator for services rendered, or with a public utility’s own variable costs of operation. Variable costs in this model are simplified into one single cost per cubic meter of water. If there is a private operator, then this variable cost can be seen as the price paid to the private operator per cubic meter of water produced or sold. If all operations are managed by the public utility, then the cost per cubic meter would simply be the public utility costs. The user can define how this cost per cubic meter changes over time, and also whether the cost per cubic meter should be assessed on the cubic meters of water produced, of water sold, or of water billed and collected.

In example 9, the per cubic meter variable cost in the base year is 3 Rs and will increase with inflation. The variable cost is assessed per cubic meter billed and collected. This approach is consistent with having a private operator that is paid based on revenue collected.

Investments and investment financing
The model user can enter two kinds of capital investments that the water utility will make in the future—the final phases of large-scale investment projects that are already underway, and large-scale investment projects that the utility is considering implementing in the future. The investment projects that are already underway are included in the baseline infrastructure scenario (see text Box 2). The future investment projects are called Project 1 and Project 2 in the CFEM model. In the Excel spreadsheet and in the user interface, the model user can define the total cost of these projects, the timing of project phases, the impact of the projects on utility operations, and how the projects will be financed.

Financing is the only characteristic of the infrastructure investment projects that can be manipulated in the user interface. Figure 10 shows page 7 of the user interface, on which the user can change assumptions about how the baseline infrastructure scenario will be financed. Similar pages exist for Project 1 and for Project 2.

As Figure 10 shows, the investment budget for the baseline infrastructure scenario is divided in two pieces: capital expenditure funded through equipment finance and capital expenditure funded in other ways. How much of the baseline infrastructure scenario would be funded in each way is defined on the Excel spreadsheet. In the user interface, the model user can change the terms of the financing.

In the example in Figure 10, the terms of the equipment finance are as follows: interest rate of 15%, repayment beginning in 2006, payment in 30 annual installments, and 20% of the equipment finance budget will be given as a grant-in-aid. Other capital expenditure is financed through two different financial instruments (40% each), a general subsidy from the central government (5%), and some self-financing from the utility (15%). The user has also defined the terms of each of the two financing instruments.
Operating deficit

Until the sector reaches financial equilibrium, the funds deficit must be covered in some way. In practice, fund deficits often result in reduced maintenance or reduced system expansion. In this model, on the other hand, expenditures on maintenance and investments are held constant, and the cash deficit is funded with a commercial loan.

The model user can define the payment conditions and interest rate on the commercial loan on page 6 of the user interface. Figure 11 shows example terms for the short-term operating loan – interest rate of 7 percent, a two-year grace period, and payment in four annual installments. These terms would apply to the operating deficit that the utility acquires in each year of the CFEM model.
Another key assumption in the CFEM model is the assumption about efficiency of utility operations. The model incorporates two types of efficiency: technical efficiency and commercial efficiency. Technical efficiency is defined as 1 – the percent of water lost in distribution and production. Commercial efficiency is the percent of revenue billed that is collected.

On page 6 of the user interface, the model user must choose to run the model with “basic” or “advanced” efficiency assumptions. (See Figure 11) The basic assumption is that both technical and commercial efficiency will remain constant over time. If the user chooses this option, than the technical and commercial efficiency estimates that are entered on page 6 of the model will be applied in every year of the CFEM model. The “advanced” assumption option allows the user to vary either or both types of efficiency over time. For example, one would expect commercial efficiency to improve over time if a private operator that was compensated based on revenue collected took over the system.
Inflation and taxes

On page 2 of the model, the user also change the inflation rate, the corporate tax rate relevant to the water utility, and the value added tax rate applied to water bills. These rates are assumed to remain constant over time. (See Figure 6).
I.5. Running the model and model output

To run the CFEM model, the user first click through pages 2-7 of the user interface. This process allows the model user to see and/or modify the basic assumptions that will underlie the model’s financial results.

On page 8 of the user interface, the user takes the final steps to define the scenario for which the model will generate financial results. (See Figure 12). Here the user must choose:

1. an infrastructure investment scenario (baseline, Project 1, Project 2, or Project 1 + 2)
2. the target year of financial equilibrium
3. how the water deficit will be imposed across customer classes,
4. the tariff growth formula before equilibrium (uniform rate of increase across customer classes, varied rate of increase across classes, defined tariff or no defined tariff at some point in the future before financial equilibrium),
5. the average tariff per customer group in the base year, and
6. the tariff growth rate after equilibrium.

Figure 12:
Setting central assumptions and running the CFEM model
After running the model, the user can view the model results in many ways. Page 9 of the user interface provides the option of seeing model results as graphs or of printing out reports. (See Figure 13)

Two different types of graphs and reports are available – financial results (e.g. tariff levels and cash balances) and assumptions underlying the results (water use assumptions and assumptions about service coverage).

Of the 6 graphs that are available, three report financial results and three graphically depict assumptions. The three financial graphs show:

1. the projected average tariff level for each customer group over time,
2. the cash balance of the utility over time,
3. the percentage of the utility’s total revenues that can be attributed to each customer group in each year,

The following graphs of assumptions are available:

1. water use by customer class over time,
2. number of people in each customer class served by the utility over time,
3. comparison of the water use assumptions behind the financial results and the default CFEM water use assumptions.

Printed reports are available of:

1. annual balance sheets,
2. annual statements of profit and loss,
3. assets,
4. financing, and
5. water use.

It is also possible to print the entire Excel worksheet.
Figure 13:
Model output page of the user interface
I.6. Model limitations

The cash flow equilibrium model has numerous limitations that users must consider when using the model and interpreting the results.

**Elasticities of demand for water**

One critical weakness in previous versions of the cash flow equilibrium model was the absence of the effects of price and income elasticities of demand on water use, and thus in the revenue projections. The models assumed by default that water consumption would remain the same regardless of how much the price of water increased or incomes changed over time. This is clearly an incorrect assumption, but it is also a difficult problem to eliminate in the Excel-based software platform of this cash flow equilibrium model.5

To better understand the problem, consider a case where the government implements a major reform of the water section. The government first improves the quality and reliability of service and then raises prices to pay for the improvements. Assume further that incomes are rising over time.

For individual j, water use in the initial period (when water is priced at P1) would be Q1. (Figure 14) Improvements to the quality and reliability of the service would lead to an outward shift of the demand curve; the individual would demand more water at every price. As long as the price of water stays at P1, individual j will consume Q2 liters of water per day. (Figure 15) But once the price is increased to P3 to pay for the reforms, the individual will reduce water consumption to Q3 (Figure 16). Over time, the gradual increase in household income will also cause an outward shift of the demand curve. (Figure 17) This income effect will increase the individual’s water use to Q4 liters per capita per day.

Whether Q4 is greater or less than Q1 will depend on the magnitude of the price, quality, and income effects. It is very difficult to predict the combined impact of all three effects. Simply correcting the revenue projections for price effects (as previous versions of the CFEM have proposed though not attempted) would not be sufficient to generate correct estimates of water sales revenue following a water system reform.

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5 It is, however, not a difficult problem to solve with more powerful optimization software.
Figure 14

Price elasticity of water use: effects

- In the base scenario before reform, a market equilibrium exists at average tariff, $P_1$, and water use, $Q_1$.

Household demand curve (individual)

Figure 15

Price elasticity of water use: effects

- After the reform process improvement in quality of water supply causes outward shift of demand.
- Quantity demanded, at the same price $P_1$, increases to $Q_2$.

Household demand curve (individual)
Figure 16

Price elasticity of water use: effects

- Utility raises tariffs to seek financial equilibrium
- The quantity demanded reduces as the point of equilibrium shifts along the demand curve to $P_3$, $Q_3$

Household demand curve (individual)

Figure 17

Price elasticity of water use: effects

- Economic development and income effects cause further outward shift of the demand curve
- Final equilibrium is reached at $(P_3, Q_4)$
- $Q_4 > \leq Q_1$

Household demand curve (individual)
The Excel platform is not sufficiently powerful to solve this problem with water use prediction. Nonetheless, the version 1.01 of the cash flow model highlights the potential importance of this problem by presenting to the user in the output section of the user interface a clear picture of the calculated tariff increases alongside the water use assumptions for each customer class. If the user no longer believes these water use assumptions are reasonable (in light of the calculated tariff increases, expected changes in household income, or predicted improvements to the water supply system), then the user can specify new water use assumptions, and the model will show the recalculated revenues (at the same tariff level).

Figure 18:
Changing assumptions about water use over time

After changing the water use assumptions, the user clicks on “output” to see a table of the difference between the revenue collected from each customer class under the constant water use assumption and under the new revised water use assumptions. A graph of how the water use

---

6 These revised water use assumptions may vary over time as well as customer classes.
assumption changes affect the cash balance of the utility is also available. This graph gives the user a sense of how much faster or slower the water utility could reach financial equilibrium if the assumption that water use remains constant over time (regardless of price) did not hold.

Operating deficit

A second key weakness in the CFEM is the way the operating deficit is addressed in the model. The model assumes that the operating deficit will be funded with a short to medium length commercial loan. The model calculates what the required size of this commercial loan would be in each year, as well as what the utility would have to pay each year in interest, commissions, and repayment of principal on these loans.

The problem is that these payments are not taken into consideration in the calculation of the utility’s financial position in each year. The operating deficit loan does not figure anywhere on the utility’s balance sheet. As section II will show, the balance sheet is the center of the CFEM model. The goal seek formula operates through the balance sheet. Because the operating deficit loan does not appear in the balance sheet, the percent annual increase in average tariff that the model solves for will not be high enough to cover repayment of this loan and still have a true nonnegative cash balance (i.e. if the operating deficit loan were considered) in the user-chosen year of financial equilibrium. The larger the deficit in the first year, the larger this problem will be.

The reason that version 1.01 and all previous versions of the model do not include the operating deficit loan in the balance sheet is similar to the technical reason for leaving price elasticity of demand out of the models. Adding the operating deficit loan to the balance sheet would create a circular equation that might not converge to a solution in Excel. Figure 19 is a simplified picture of the problem.

Excel’s goal seek function solves for the percent annual increase in average tariff that will bring the utility into financial equilibrium (eliminate negative cash positions). Goal seek uses interpolation to solve for the percent increase. With each potential solution that Excel tried in the interpolation process, the size of the loan that would be needed to cover the operating deficit would also change (because revenues had changed). Taking on a different size loan would alter the expense side of the utility’s financial equation. This would in turn change the size of the deficit that the utility was trying to overcome with tariff increases… There is no guarantee that Excel would be able to solve this type of circular equation.

In the Excel spreadsheet, it is possible for the model user to see how incorporating the operating deficit loan in the balance sheet would change the financial results for the utility (at the tariff level solved for by the model). The spreadsheet presents the annual cash surplus/deficit without the operating deficit loan, and the annual cash flow related to the operating deficit loan (loan funds received – capital repayment – interest paid – commissions paid). These are added together to find the annual cash surplus/deficit with the operating deficit loan. The cumulative sum of cash surpluses/deficits with the commercial loan can than be compared to the CASH position on the balance sheet in the model (cumulative sum of cash surpluses/deficits without the commercial loan).
Like the sensitivity analysis for demand elasticities, the results in the Excel spreadsheet give the user some sense of the magnitude of the error in the model due to the exclusion of the operating deficit loan. They also show how large a credit line the utility would need to funds its operating deficit until it started to generate positive cash balances.

Figure 19:
Circular equations surrounding the operating deficit

Cash surplus after equilibrium

This model solves for the annual percent increase in average tariff that will be necessary to bring the utility to financial equilibrium in a user-defined year. After equilibrium, the user can choose the annual rate of increase in the average tariff for each customer class. If average tariffs are set to increase at a faster rate than variable costs, then the utility’s cash position will rise steadily over time after reaching financial equilibrium. Even if variable costs and tariffs increase at the same rate over time, the utility could still increase its cash position over time (e.g. if the utility’s service expansion area were growing). The model could thus show the utility increasing its profit over time, rather than maintaining a position of financial equilibrium. In reality, policy makers are unlikely to accept growing profits by public utilities, at least if those profits are not reinvested in system improvements. It is therefore important not to make too much of financial results after the user-defined year of financial equilibrium.
Costs versus output

The model contains very few forced links between costs and utility output. For example, the model does not check to see that the funds allocated for system expansion are in fact sufficient to cover the cost of the user-defined rate of system expansion. Nor does the model evaluate whether additional investment in system expansion would be needed to permit non-residential water consumption to expand at the projected rate. It is the responsibility of the model user to ensure that the cost calculations are reasonable estimates for the user-defined scenarios. Sensitivity analysis (which is facilitated by the user interface) can help policy makers evaluate how changes in assumptions about costs and about utility output (e.g. number of connected users) would affect the model results.

Tariff structure

This model projects changes in average tariff levels. In practice, average tariffs must be translated into a tariff structure – a formula for calculating customer bills. Common tariff structures include increasing block tariffs, uniform volumetric charges, two-part tariffs, etc. Customers respond to the specifics of the tariff structure, not the average tariff, when deciding how much water to consume. Moreover, tariff structures, not just average tariff levels, can have important distributional impacts. Even after this model calculates how average tariffs would need to change over time to achieve financial equilibrium, there is still more work to be done.

Sanitation

This version of the cash flow equilibrium model considers a utility that only provides water. Many utilities actually offer both water and sewer service, and their tariff structures can incorporate cross-subsidies across these two services. The basic structure of this model could be expanded to include a second service, if this were necessary for application to a particular case.
II. Digging into the model: Structure of the spreadsheet

CFEM’s user interface eliminates the need to go back into the Excel spreadsheet to modify some of the most important assumptions behind the model results. Only the advanced model user will need to understand how to work in the Excel spreadsheet itself.

When the CFEM file is first opened, all traces of the Excel workbook and worksheets are hidden; only the user interface is visible. To enter the spreadsheets, the user must click on “CFEM Version 1.01” in the upper left-hand corner of the screen and then choose the option “Edit Application”. This reveals all of the worksheet tabs.

Most of the worksheets in the CFEM Excel workbook relate to the user interface. The model user need not open these worksheets at all. Only three worksheets will be important to the model user who is trying to enter data about a particular case or change assumptions in the model. These three worksheets are titled: Model, Project Info, and Input_Customer Class.

Color coding on these worksheets helps the model user identify all the cells that must be filled in for the model to function and also to differentiate input cells from output cells.

- Light blue cells require user input: the model user must feed data into these cells, either through the user interface or directly in the spreadsheets.
- White cells do not require user input: the model calculates the numbers in these cells based on the data entered in the light-blue cells.
- Green cells provide totals in different subsections of the spreadsheet.
- Yellow cells are summary cells. Yellow sections of the spreadsheet provide summaries of long subsections of the model.
- Grey marks tables that contain model results, such as the balance sheet and the flow of funds statement.

To further facilitate use of the spreadsheet, we have added “+” and “-“ to the left-hand side of the spreadsheets. Clicking on the minus sign hides many rows of the spreadsheet, leaving only titles and totals of different subsections of the spreadsheet. Clicking on the plus sign expands the spreadsheet to reveal the underlying rows.

Pluses and minuses on the top of the worksheets have a similar function. These are used to hide and reveal columns (years) of data.

II.1. “Model” worksheet

CFEM Version 1.01 preserves the one-sheet model format that was popular with the creators of the original cash flow equilibrium model. Virtually all of the data and all of the output tables are included on this one sheet.

The Model worksheet is organized as follows.

- income and costs
- net assets.
II.2. “Project info worksheet”

The project information worksheet is where the model user describes the cost and timing of proposed new capital investments. (Figure 20) The model user can name the project and plan up to three phases of project work. For each phase, the model user must enter the total value of capital investment in each year that will be funded by equipment finance and that will be funded in some way other than equipment finance (e.g. loan). Finally, the model user decides how the assets in each phase should be depreciated over time.

Figure 20: Project info worksheet
II.3. “Input customer class”

This worksheet is used to set the default customer classes and default water use projections for each class. The CFEM already has default classes and water use projections that were chosen by the model builders. But these defaults can be modified by the model user if desired.

III. Digging into the model: behind the balance sheet

This section of the user manual traces the web of equations in the CFEM, using the balance sheet as a starting point. It is intended for the model user who wants to understand more precisely how the model operates. Key relationships in the model are presented in equation form. (See Appendix 1 for variable definitions). The subscripts on the variables in this section of the user manual mean the following: i for year, j for infrastructure investment scenario, and k for customer class.

III.1 The balance sheet

<table>
<thead>
<tr>
<th>Balance Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assets_{ij} =</td>
</tr>
<tr>
<td>ASSETSNET_{ij} + CURRENTASSETS_i + CASH_{ij}</td>
</tr>
<tr>
<td>Equity + Liabilities_{ij} =</td>
</tr>
<tr>
<td>CAPITAL_i + PROFLOSSCUM_{i-1,j} + PROFAFTERTAX_{ij} + DEBTLT_{ij} + EQUIPFINLT_{ij} + SUBSIDIES_{ij} + CURRENTLIABILITY_i</td>
</tr>
</tbody>
</table>

The center of the cash flow equilibrium model is the balance sheet. The balance sheet for each year i and infrastructure investment scenario j has two components: assets, and equity and liabilities. The goal seek function in the cash flow equilibrium model searches for the percent annual increase in average tariff that will make CASH_{ij} = 0 in the user-defined year of financial equilibrium.7 As Assets always equal Equity + Liabilities, \( CASH_{ij} = (Equity + Liabilities_{ij}) - ASSETSNET_{ij} - CURRENTASSETS_{ij} \).

7 The balance sheet is the core of the CFEM model, but the model also produces another financial statement that provides an alternative way of looking at the utility’s cash position—the flow of funds statement. The flow of funds statement compares uses of funds to sources of funds and calculates the annual fund deficit or the annual fund surplus. In the year that the water utility reaches financial equilibrium, the cumulative sum of annual funds deficits or surpluses equals zero. From the financial equilibrium point forward, the utility’s sources of funds exceed uses of funds every year.

The flow of funds statement is not essential to the model, but is a good check on the functioning of the model. The goal seek function in the CFEM runs with the balance sheet definition of financial equilibrium. If after running the model, the cumulative sum of annual funds deficits or surpluses does not equal zero in the year of financial equilibrium, then there is a problem with the model somewhere. (See Flow of Funds equations on next page).
The remaining sections in this chapter of the user manual look more closely at the variables in the balance sheet equation. Section III.2 explains how profit after tax (or PROFAFTERTAX) and cumulated profit and loss (PROFLOSSCUM) are calculated through annual profit/loss statements. Section III.3. examines net assets (ASSETSNET). The focus of section III.4. is capital investment financing: long-term debt (DEBTLT), equipment finance (EQUIPFINLT), and subsidies (SUBSIDIES). Section III.5. addresses current assets and current liabilities. Section III.6. explains the CAPITAL variable in the balance sheet equations.

III.2. Profit after tax and cumulative profit/loss

<table>
<thead>
<tr>
<th>Profit and loss statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ \text{PROFAFTERTAX}_{ij} = ]</td>
</tr>
<tr>
<td>+ Operating profit =</td>
</tr>
<tr>
<td>\hspace{1cm} + \text{OPERREVWAT}_{ij}</td>
</tr>
<tr>
<td>\hspace{1cm} + \text{OPERREVOTHER}_{i}</td>
</tr>
<tr>
<td>\hspace{1cm} - \text{OPERCOSTFIX}_{ij}</td>
</tr>
<tr>
<td>\hspace{1cm} - \text{OPERCOSTVAR}_{ij}</td>
</tr>
<tr>
<td>\hspace{1cm} - \text{DEPRECALLOCC}_{ij}</td>
</tr>
<tr>
<td>+ Non operating income =</td>
</tr>
<tr>
<td>\hspace{1cm} + \text{NONOPERREV}_{i}</td>
</tr>
<tr>
<td>\hspace{1cm} + \text{PROVISALLOC}_{i}</td>
</tr>
<tr>
<td>\hspace{1cm} + \text{PROVISBACK}_{i}</td>
</tr>
<tr>
<td>\hspace{1cm} + \text{DEPRECBACK}_{ij}</td>
</tr>
<tr>
<td>- \text{INTEREST}_{ij}</td>
</tr>
<tr>
<td>- \text{COMMISSION}_{ij}</td>
</tr>
<tr>
<td>- \text{TAX}_{i}</td>
</tr>
</tbody>
</table>

The profit/loss statements in the CFEM calculate \( \text{PROFAFTERTAX}_{ij} \) for each year. Profit after tax equals operating profit plus non-operating income, minus interest and commissions on loans, minus tax paid. \( \text{PROFLOSSCUM}_{i-1,j} \) is the cumulative value of after-tax profit or loss in previous year (cumulative earnings put in reserve).

\[ \text{PROFLOSSCUM}_{i-1,j} = \sum_{\text{year } 0 \text{ to year } i-1} \text{PROFAFTERTAX}_{ij} \]

Uses of funds:
\[ \text{WORKCAPINCR}_{ij} + \text{INTANGINC}_{i} + \text{FINANCINC}_{i} + \text{TANGIBLEINC}_{ij} + \text{PRINCIPALREPAY}_{ij} \]

Sources of funds:
\[ \text{WORKINGCAPDEC}_{ij} + \text{SELFFINANCE}_{ij} + \text{INTANGDEC}_{i} + \text{FINANCDEC}_{i} + \text{TANGIBLEDEC}_{ij} + \text{CAPITALCHANGE}_{i} + \text{EQUIPFINNEW}_{ij} + \text{DEBTNEW}_{ij} + \text{NEWGRANTS}_{ij} + \text{NEWGENSUBSIDIES}_{ij} \]

The utility uses funds to purchase new assets (intangible assets, financial assets, or tangible assets), to increase its working capital, or to repay the principle on outstanding loans. The utility obtains funds by selling assets, decreasing its working capital, increasing its revenue, increasing equity capital, obtaining new loans, or obtaining subsidies.
Revenues from water sales (OPERREVWAT)

Sales of water are the primary revenue base of the utility in the CFEM. Revenues from water sales are a function of (1) the tariffs applied in each customer class (AVGTARIFF\_ijk), (2) the water sold to each residential and non-residential customer class (ADJWATUSER\_ijk and ADJWATUSENR\_ijk), and (3) commercial efficiency (COMMEFFIC\_i).

\[
\text{OPERREVWAT}_{ij} = \text{COMMEFFIC}_i \times \sum_{\text{all } k} (\text{AVGTARIFF}_{ijk} \times (\text{ADJWATUSER}_{ijk} \text{ or ADJWATUSENR}_{ijk}))
\]

Commercial efficiency equals the percent of water sold for which revenue is collected. This is assumed to be constant across investment scenarios and across customer classes. Section I.3 of the user manual and Appendix 3 describe how version 1.01 of the model calculates unadjusted and adjusted water use estimates for both residential and nonresidential customers. Section I.2 and Appendix 2 describe how the goal seek formula generates the tariffs for each customer class.

Operating income from services other than water sales (OPERREVOTHER)

The CFEM model also has room for additional operating revenue for the utility – revenue from something other than water sales. These revenue calculations are not derived from any other part of the model. The model user simply enters the predicted OPERREVOTHER for each year in the Excel spreadsheet. The model assumes that this revenue will be the same across infrastructure investment scenarios.

Operating costs (OPERCOSTFIX, OPERCOSTVAR, PERCOSTFIX)

As described in section I of the user manual, the CFEM model incorporates three different types of costs: fixed operating costs, fixed personnel costs, and variable operating costs (including personnel).

The variable operating costs are based on a per cubic meter price that is defined by the user (VARCOSTUNIT\_i). This cost is constant across investment scenarios. The variable operating cost may be assessed on the cubic meters of water produced, of water sold, or of water billed and collected. If residential water use (RESWATUSE\_ij) equals the sum over all residential k of ADJWATUSER\_ij and nonresidential water use (NONRESWATUSE\_ij) equals the sum over all nonresidential k of ADJWATUSENR\_ij, then variable operating cost will equal one of the following three sums:

\[
\text{OPERCOSTVAR}_{ij} = \\
(1) \text{VARCOSTUNIT}_i \times [(\text{RESWATUSE}_{ij} + \text{NONRESWATUSE}_{ij}) \times (1 + (1 - \text{TECHEFFIC}_i))]\\
(2) \text{VARCOSTUNIT}_i \times [(\text{RESWATUSE}_{ij} + \text{NONRESWATUSE}_{ij})]\\
(3) \text{VARCOSTUNIT}_i \times [[[\text{RESWATUSE}_{ij} + \text{NONRESWATUSE}_{ij}]]] \times \text{COMMEFFIC}_i
\]
Fixed operating and personnel costs may vary across infrastructure investment scenario. The user defines how much larger or smaller fixed operating and personnel costs would be (over the baseline scenario) if a particular investment scenario were implemented. This is done by defining a fixed operating cost factor (OPCOSTFACTORj) and a fixed personnel cost factor (PERCOSTFACTORj) for each infrastructure investment scenario. The factors are equal to the percent difference in costs between fixed operating or personnel costs in the baseline infrastructure scenario and these costs in each of the other infrastructure investment projects.

Fixed operating costs and fixed personnel costs may also vary across time (reflecting price changes and also growth of the utility) The user defines the annual percentage increase in baseline fixed operating and personnel costs (OPCOSTINC and PERCOSTINC)\(^8\). For fixed operating costs, the relevant equations are:

\[
\begin{align*}
\text{OPERCOSTFIX}_{i0} &= \text{OPERCOSTFIX}_{i-1,0} \times (1 + \text{OPCOSTINC}) \\
\text{OPERCOSTFIX}_{ij} &= \text{OPERCOSTFIX}_{i-1,j} \times (1 + \text{OPCOSTINC}) \times (1 + \text{OPCOSTFACTOR}_j)
\end{align*}
\]

In the case of personnel costs, the model includes three additional variables that help the user incorporate staffing changes that may be taking place during the reform process. STAFFCHANGE\(_i\) is a sum that is added to or subtracted from personnel costs in year \(i\), above and beyond the predicted annual PERCOSTINC. PENSIONS and OTHERPERS allow the user to add two annual personnel costs (such as indemnities for retirement) that does not increase annually at the rate of PERCOSTINC and is not affected by the infrastructure investment scenario.

\[
\begin{align*}
\text{PERCOSTFIX}_{i0} &= \left[ \left( \text{PERCOSTFIX}_{i-1,0} \pm \text{STAFFCHANGE}_{i} \right) \times (1 + \text{PERCOSTINC}) \right] + \text{PENSIONS}_i + \text{OTHERPERS}_i \\
\text{PERCOSTFIX}_{ij} &= \left[ \left( \text{PERCOSTFIX}_{i-1,j} \pm \text{STAFFCHANGE}_{i} \right) \times (1 + \text{PERCOSTINC}) \times (1 + \text{PERCOSTFACTOR}_j) \right] + \text{PENSIONS}_i + \text{OTHERPERS}_i
\end{align*}
\]

Nonoperating revenue (NONOPERREV)

Utilities may also have nonoperating revenue. In the CFEM, the non-operating revenue calculations are not derived from any other part of the model. The model user simply enters a predicted non-operating revenue figure for each year in the Excel spreadsheet. The model assumes that this revenue will be the same across infrastructure investment scenarios.

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\(^8\) The CFEM allows the user to break down fixed operating costs into five subcategories. MATERIALS\(_i\) + TRANSPORT\(_i\) + OTHCHARGE\(_i\) + OTHSERVICE\(_i\) + INSURANCE\(_i\). But all five subcategories are predicted to increase across time at the same rate: OPCOSTINC.
Allocations and write-backs for depreciation and other provisions

In the CFEM model, annual allocations for depreciation of tangible, intangible, and financial assets are subtracted from operating revenue to arrive at an estimate of operating profit. The model has two options for the calculation of depreciation on these assets – a built-in depreciation formula, or the option for the user to calculate depreciation outside the model and simply enter the results.

Write-backs of depreciation allocations, and both allocations and write-backs for provisions (usually required by law of the utility), are included as part of the nonoperating income calculation. DEPRECBACK, PROVISALLOC and PROVISBACK for each year in the model are defined by the user in the Excel spreadsheet. These variables are not derived from any other part of the model.

Interests and commissions

INTEREST_{ij} and COMMISSION_{ij} are the interests and commissions that the utility must pay each year to financial institutions for the lending program. More detail on these variables is provided below in the section on financing.

Tax

The CFEM assumes that the utility will be taxed at a user-defined corporate tax rate. The tax is only levied, however, in the years that the utility does not report a deficit. The reported deficit equals 0 (i.e. the utility does not report a deficit) if PROFLOSSCUM_{i-1,j} + Operating profit_{i} + Non-operating revenue - INTEREST_{ij} - COMMISSION_{ij} > 0. When a corporate tax is applied, the total tax payment equals TAXRATE times (Operating profit_{i} + Non-operating revenue - INTEREST_{ij} - COMMISSION_{ij}).

III.3. Net assets

The utility in this model has three types of assets – intangible assets, financial assets, and tangible assets. The structure used for tracking the assets across time is the same for all three types of assets.

In each year, the model records the gross value of the assets at the beginning (ASS_OP) and at the end of the year (ASS_CL), accounting for any increases or decreases in the assets made during the year. Similarly, depreciation of these assets at the beginning (DEPR_OP) and at the end of the year (DEPR_CL) is recorded. Finally, the net value of the assets at the end of the year is calculated by subtracting depreciation at the end of the year from gross value of the assets at the end of the year (ASS_CL – DEPR_CL).

This calculation is separately done for each of the three types of assets and then the total net value of all assets is calculated (NETASSETS). NETASSETS is the asset variable that enters the balance sheet.
Intangible assets and financial assets (NETINTANGIBLE, NETFINANCIAL)

The CFEM treats intangible assets and financial assets in similar manners. These assets do not vary across infrastructure investment scenarios. One difference between the two types of assets in CFEM is that there is only one category of intangible assets in the model (INTANGASS), whereas financial assets (FINANCEASS) are broken down into the following categories: shares, advances outside projects, and advances and accounts. Because the formulas for intangible assets and financial assets are the same, the equations will only be presented once, for the case of intangible assets.

The model user must define the gross value of INTANGASS_OP and INTANGASS_CL in the base year. The user also defines INTANGINC and INTANGDEC in each year: the increase and decrease in the stock of intangible assets during the year.

Depreciation on these assets at the beginning and end of the year (INTANGDEPR_OPi and INTANGDEPR_CLi) are linked by allocations to depreciation for those assets during the year (INTANGDEPINC_i) and write backs of depreciation in the same year (INTANGDEPDEC_i)

\[
\begin{align*}
\text{INTANGASS}_{\text{OP}i} &= \text{INTANGASS}_{\text{CL}(i-1)} \\
\text{INTANGASS}_{\text{CL}i} &= \text{INTANGASS}_{\text{OP}i} + \text{INTANGINC}_i - \text{INTANGDEC}_i \\
\text{INTANGDEPR}_{\text{CL}i} &= \text{INTANGDEPR}_{\text{OP}i} + \text{INTANGDEPINC}_i - \text{INTANGDEPDEC}_i \\
\text{NETINTANGIBLE}_{ij} &= \text{INTANGASS}_{\text{CL}ij} - \text{INTANGDEPR}_{\text{CL}ij}
\end{align*}
\]

Tangible assets

Tangible assets are divided into two general categories in the model:
- Tangible assets related to the baseline infrastructure scenario. These assets include: (1) Assets acquired before base year, (2) existing continuing investments, and (3) future capital investments that are already pre-programmed (do not include Project 1 or Project 2 – proposed infrastructure investments)
- Tangible assets related to each of the three new proposed infrastructure investment scenarios (Project 1, Project 2, and Project 1 + 2)

The following conditions also hold for tangible assets:

\[
\begin{align*}
\text{TANGASS}_{\text{OP}ij} &= \text{TANGASS}_{\text{CL}(i-1)j} \\
\text{TANGASS}_{\text{CL}ij} &= \text{TANGASS}_{\text{OP}ij} + \text{TANGINC}_{ij} - \text{TANGDEC}_{ij} \\
\text{TANGDEPR}_{\text{CL}ij} &= \text{TANGDEPR}_{\text{OP}ij} + \text{TANGDEPINC}_{ij} - \text{TANGDEPDEC}_{ij} \\
\text{NETTANGIBLE}_{ij} &= \text{TANGASS}_{\text{CL}ij} - \text{TANGDEPR}_{\text{CL}ij}
\end{align*}
\]
Unlike intangible assets and financial assets, tangible assets vary across infrastructure investment scenarios. CFEM separately calculates NETTANGIBLE for each infrastructure project. The totals are then added together to derive NETTANGIBLE for each infrastructure investment scenario (e.g.: NETTANGIBLE for the Project 1 scenario would equal net tangible assets for Project 1 plus net tangible assets for (1) assets acquired before base year, (2) existing continuing investments, and (3) future capital investments that are already pre-programmed.)

The model user can enter and change TANGINCij for each year and each investment scenario through the “project info” worksheet in the Excel spreadsheet (See Figure 20). The model user enters the phased investment plan for each project. TANGINCij is the sum of all capital investment programmed in year i for investment scenario j.

The project info worksheet also has a place for the model user to decide how these capital investments should be depreciated (i.e. number of years over which to depreciate the investments).

### III.3. Financing of investments

There are many different financing possibilities for infrastructure investments. CFEM Version 1.01 divides the universe of options into two major groups – equipment financing and other financing. Equipment financing involves buying equipment with a financing plan directly from the supplier. Other financing options include loans, subsidies, and investments made with the utility’s own resources.

The model user must use the project information worksheet (as in Figure 20) to record the timing and magnitude of the capital expenditure required in the baseline infrastructure scenario; in Project 1, and in Project 2. In the user interface, the model user can then decide how this capital expenditure will be financed and what the financing conditions will be. (See Figure 10)

#### Equipment Finance

For equipment financing, the model user first defines what percentage of the total equipment financing bill will be given as grant-in-aid. The remaining amount is financed at a user-defined interest rate, with repayment beginning in a user-defined year and lasting for a user-defined number of payments. Excel then calculates what the principal and interest payments will be each year. If applicable, the model user can also enter any commissions and charges associated with the equipment financing for each project.

The EQUIPFINLTij variable in the balance sheet is the equipment finance balance that is still outstanding in year i in infrastructure scenario j.

\[
\text{EQUIPFINLT}_{ij} = \text{EQUIPFINLT}_{i-1,j} + \text{EQUIPFINNEW}_{ij} - \text{EQUIPFINREPAY}_{ij}
\]
Long term debt

For all capital expenditure not funded with equipment financing, the model user decides what percentage will be funded with each of the following: financing instrument 1, financing instrument 2, general subsidies, and the utility’s own resources. The expenditures funded with the two generic financing instruments (plus any pre-existing debts) make up the utility’s long-term loan portfolio.

As with equipment financing, the model user may choose the interest rate, year of first payment, and number of payments for each financing instrument. A percent of the total can also be provided as grant-in-aid.

The DEBTLT$_{ij}$ variable in the balance sheet is the debt balance that is still outstanding in year $i$ and infrastructure investment scenario $j$

$$DEBTLT_{ij} = DEBTLT_{i-1,j} + DEBTNEW_{ij} - PRINCIPALREPAY_{ij}$$

Subsidies

SUBSIDIES$_{ij}$ is the cumulative balance of capital subsidies provided to the utility. This includes grants-in-aid provided as parts of equipment financing packages or other financial instruments. It also includes general subsidies provided to the utility from the government. The percentage of capital expenditure in new projects that will provided as a subsidy or grant is defined by the user in the user interface.

$$SUBSIDIES_{ij} = SUBSIDIES_{i-1,j} + NEWGRANTS_{ij} + NEWGENSUBSIDIES_{ij}$$

II.4 Current assets, current liabilities, and working capital

Current assets

The current assets variable on the balance sheet (CURRENTASSETS$_{ij}$) is the sum of suppliers’ credit (accounts payable) and amounts owed to other sundry creditors.

Suppliers credit (SUPPLYCRED) is the running tab that the utility owes to its suppliers. To estimate this running tab, the model first figures out what the utility’s total expenditures were during the year. Total expenditures (TOTUTILEXP$_{ij}$) equals operating expenses plus new investments that were funded with the utilities own funds during the year (derived from financing plan for infrastructure investment scenarios). Next the model user must define the average number of months that bills to suppliers are left unpaid (SUPPLYMONTHS$_{ij}$). SUPPLYMONTHS can vary over time, but is assumed to remain the same in all investment scenarios.
SUPPLYCRED_{ij} = \text{TOTUTILEXP}_{ij} \times (\text{SUPPLYMONTHS}_{i}/12)

Other payables include: (1) VAT (value added tax) on uncollected water sales revenue, (2) VAT on other uncollected revenue, and (3) other. VAT on uncollected water sales and other revenue is equal to the user-defined VATRATE (which is assumed to stay constant over time) times the credit provided to customers and other debtors (accounts receivable).

Current liabilities

The current liabilities variable in the balance sheet (\text{CURRENTLIABILITY}_{ij}) is the sum of clients’ credit (accounts receivable) and credit provided to other sundry debtors. Clients’ credit is the running tab of unpaid water bills. CFEM estimates clients’ credit based on the average number of months it takes clients to pay their bills (\text{CLIENTMONTHS}), and the total value of the bills that were sent out during the year.

\text{CLIENTCRED}_{ij} = \text{OPERREVWAT}_{ij} \times (\text{CLIENTMONTHS}_{i}/12)

For credit provided to other debtors, the model user has a few choices. One option is to simply use the existing three categories (unpaid bills related to elimination of meters, unpaid bills related to other services, and other unpaid) and define the value of credit provided in each category at the end of the year. Another option is to use the “outstanding bills as a percent of revenue” option. For this option, the user defines what percent of revenue on average equals the credit provided to debtors (other than water bills) each year. The model then automatically calculates an estimate of credit provided to these other sundry debtors.

Working capital

The utility’s working capital is equal to \text{CURRENTASSETS}_{ij} + \text{CURRENTLIABILITY}_{ij}. The increase and decrease in working capital variables that are included in the flow of funds statement (see footnote 7) are defined as follows:

\text{WORKCAPINCR}_{ij} =
\text{(CURRENTASSETS}_{ij} + \text{CURRENTLIABILITY}_{ij}) - \text{(CURRENTASSETS}_{i-1,j} + \text{CURRENTLIABILITY}_{i-1,j}) \text{, if the sum is greater than 0 ; = 0 otherwise.}

\text{WORKCAPDECR}_{ij} =
-1 \times \{(\text{CURRENTASSETS}_{ij} + \text{CURRENTLIABILITY}_{ij}) - (\text{CURRENTASSETS}_{i-1,j} + \text{CURRENTLIABILITY}_{i-1,j})\} \text{, if the sum is greater than 0 ; = 0 otherwise.}

II.5. Capital

\text{CAPITAL} in year i is the sum of social capital and legal reserves, state support, and required provisions. In the Excel spreadsheet, the model user enters the existing and predicted levels of social capital and legal reserves and of the account for state support in each year of the model. The user also enters assumptions about the changes in equity capital and about allocations for and writebacks of provisions in each year.
Appendix 1: List of variables

ADJWATUSER = adjusted estimate of annual water use by a residential customer class
ADJWATUSENR = adjusted estimate of annual water use by a nonresidential customer class
ASSETNET = net assets
AVAILWAT = water available for sale (total capacity * technical efficiency)
AVGTARIFF = average tariff per cubic meter of water for customer class k
CAPITAL = capital and reserves
CAPITALCHANGE = increase or decrease in capital and reserves
CASH = cumulative cash balance on balance sheet
COMMMEFFIC = commercial efficiency; percent of water bills that are collected
COMMISSION = commissions paid on equipment financing and loans
CLIENTCRED = credit provided to clients on unpaid water bills
CLIENTMONTHS = average number of months that water bills go unpaid
CURRENTASSETS = suppliers’ credit plus amounts owed to other sundry creditors.
CURRENTLIABILITY = clients’ credit and credit provided to other sundry debtors
DEBTLT = outstanding long-term debt
DEBTNEW = new long-term debt issued during year
DEFINETAR = average tariff for customer class k (as defined by model user).
DEPRECALLOC = allocation for depreciation
DEPRECBACK = write-back of allocation for depreciation
EQUIPFINLT = outstanding equipment financing
EQUIPFINNEW = new equipment finance taken out during year
EQUIPFINREPAY = repayment of principal on equipment financing
FINANCDEC = decrease in financial assets
FINANCINC = increase in financial assets
INTANGASS_CL = gross intangible assets at the end of the year
INTANGASS_OP = gross intangible assets at the beginning of the year
INTANGDEPR_CL = depreciation of intangible assets at the end of the year
INTANGDEPR_OP = depreciation of intangible assets at the beginning of the year
INTANGDEC = decrease in intangible assets during year
INTANGINC = increase in intangible assets during year
INTEREST = interest payment on loans and equipment finance
NETINTANGIBLE = net value of intangible assets
NEWSUBISIDES = increase in subsidies during year (grants in aid + general subsidies)
NEWCUST = number of new customers added to customer class k
NEWGRANTS = grants provided during year
NEWGENSUBSIDES = general subsidies provided during the year
NONOPERREV = nonoperating revenue
NONRESWATUSE = total nonresidential water use during year
OPCOSTFACTOR = percent increase in operating costs over baseline scenario
OPCOSTINC = annual percent increase in operating costs
OPERCOSTFIX = fixed operating costs
OPERCOSTVAR = variable operating costs
OPERREVOTHER = other (not from water sales) operating revenue
OPERREVWAT = operating revenue from sales of water
OTHERPERS = increase or decrease in personnel costs in year i
PCWATER_k = per capita water use in customer class k
PENSIONS = expenditure on or allocation for pensions
PERCUST_k = percent of utility customers who are in customer class k
PERCOSTINC = percent annual increase in personnel costs
PERCOSTFACTOR = percent increase in personnel costs over the baseline scenario
POPSERVED_i = population served by the utility
PRINCIPALREPAY = payment of principal on long-term loans
PROFAFTERTAX = profit after tax
PROLOSSCUM = cumulative profit and loss
PROVISALLOC = allocation for provisions
PROVISBACK = write-back of provisions
RATETARINCR_1 = annual percent increase in average tariff for customer group 1 before equil
RATETARINCR2 = annual percent increase in average tariff after equilibrium
RATETARINCR3 = annual percent increase in average tariff in years before user-defined tariff
RELRATE = relative rate of increase in average tariffs before equilibrium (relative to first class)
RESCUST = number of customers in residential customer class
RESWATUSE = annual water use by residential customers
SELFFINANCE = utility’s capacity for financing investments from own resources
STAFFCHANGE = increase or decrease in personnel costs
SUBSIDIES = total cumulative value of subsidies
SUPPLYCRED = average value of outstanding bills to suppliers (accounts payable)
SUPPLYMONTHS = average number of months bills are left unpaid
TANGIBLEDEC = decrease in tangible assets
TANGIBLEINC = increase in tangible assets
TANGASS_CL = gross value of tangible assets at the end of the year
TANGASS_OP = gross value of tangible assets at the beginning of the year
TANGINC = increase in tangible assets during year
TANGDEC = decrease in tangible assets during year
TANGDEPR_CL = depreciation of tangible assets at the end of the year
TANGDEPR_OP = depreciation of tangible assets at the beginning of the year
TANGDEPINC = increase in depreciation on tangible assets during the year
TANGDEPDEC = write-back of depreciation of tangible assets during the year
TAX = corporate income tax paid
TECHEFFIC = technical efficiency
TOTUTILEXP = utility expenditures on operating costs and investments during year
USERATE = rate of increase in water use for nonresidential customers
VARCOSTUNIT = cost per cubic meter of water
WATDEFICIT = available water minus unadjusted estimates of water use by all classes
WATPROD = water produced
WATUSE = unadjusted estimate of water use
WATUSENR = unadjusted estimate of water use by nonresidential customer class k
WATUSER = unadjusted estimate of water use by residential customer class k
WORKCAPINCR = increase in working capital
WORKINGCAPDEC = increase in working capital
Appendix 2: Tariff increase formulas

As described in section I.2. of the user manual, the CFEM uses Excel’s goal seek function to solve for the annual percent increase in the average tariff for customer group 1 that is necessary to achieve financial equilibrium (CASH=0) in a user-defined year: RATETARINCR.

The annual percent increase in the average tariff for customer group 1 is related to the average tariff applied to other customer groups by the relative rate variable (RELRATEk). RELRATEk defines the rate of increase in the average tariff for customer group k relative to the rate of increase for customer group 1.

\[ \text{RELRATE}_k = 1, \text{ for } k=1 \]

\[ \text{RATETARINCR}_{ijk} = \text{RATETARINCR}_{ij1} \times \text{RELRATE}_k, \]

RATETARINCR_{ijk} is only used to calculate the average tariffs for each customer class in the years leading up to financial equilibrium \((i<=I; \text{ when } i = I, \text{ CASH} = 0)\) After financial equilibrium, the model user chooses the rate of increase in average tariff levels: RATETARINCR2_k. This rate is constant across time, but may vary across customer groups.

Four tariff increase formulas are possible. The model user chooses which of the four to apply in the user interface.

**Basic formula: Uniform rate of change across classes, no defined tariff**

\[ \text{RATETARINCR}_{ijk} = \text{RATETARINCR}_{ij1} \text{ for all } k. \]
\[ \text{AVGTARIFF}_{ijk} = \text{AVGTARIFF}_{(i-1)jk} \times \text{RATETARINCR}_{ij1}, \text{ for all } i <=I \]
\[ \text{AVGTARIFF}_{ijk} = \text{AVGTARIFF}_{(i-1)jk} \times \text{RATETARINCR}_{2k}, \text{ for all } i >I \]

**Advanced formula 1: Rate of change varies across customer classes, no defined tariff**

\[ \text{AVGTARIFF}_{ijk} = \text{AVGTARIFF}_{(i-1)jk} \times \text{RATETARINCR}_{ijk}, \text{ for all } i <=I \]
\[ \text{AVGTARIFF}_{ijk} = \text{AVGTARIFF}_{(i-1)jk} \times \text{RATETARINCR}_{2k}, \text{ for all } i >I \]

The last two tariff increase formulas allow the user to define the tariff that will be applied in each customer group in a year (year x) before financial equilibrium (DEFINETAR_k). The user also chooses the rate of increase in the average tariff for each customer group in the years leading up to year x: RATETARINCR3_k

**Advanced formula 2: Uniform rate of change across classes, define tariff in year X**

\[ \text{RATETARINCR}_{ijk} = \text{RATETARINCR}_{ij1} \text{ for all } k. \]
\[ \text{AVGTARIFF}_{ijk} = \text{AVGTARIFF}_{(i-1)jk} \times \text{RATETARINCR}_{3ijk}, \text{ for all } i <=x \]
\[ \text{AVGTARIFF}_{ijk} = \text{DEFINETAR}_{k} \text{ for } i=x \]
\[ \text{AVGTARIFF}_{ijk} = \text{AVGTARIFF}_{(i-1)jk} \times \text{RATETARINCR}_{ij1}, \text{ for all } x < i <=I \]
\[ \text{AVGTARIFF}_{ijk} = \text{AVGTARIFF}_{(i-1)jk} \times \text{RATETARINCR}_{2k}, \text{ for all } i >I \]
Advanced formula3: Rate of change varies across customer classes, define tariff in year $X$

$AVGTARIFF_{ijk} = AVGTARIFF_{(i-1)jk} \times RATETARINCR3_{ijk}$, for all $i \leq x$

$AVGTARIFF_{ijk} = DEFINETAR_k$, for $i = x$

$AVGTARIFF_{ijk} = AVGTARIFF_{(i-1)jk} \times RATETARINCR_{ij1}$, for all $x < i \leq l$

$AVGTARIFF_{ijk} = AVGTARIFF_{(i-1)jk} \times RATETARINCR_{2k}$, for all $i > l$
Appendix 3: Adjusted and unadjusted water use estimates

1. Unadjusted water use estimates for residential customer classes (WATUSER$_{ijk}$)

Water use by each residential customer group equals the number of customers in that customer group (RESCUST) times the average per capita water use in that group (PCWATER). The following equation is for WATUSER$_{ijk}$ – unadjusted water use by residential customer class k in year I and infrastructure investment scenario j.

\[
WATUSER_{ijk} = RESCUST_{ijk} \times PCWATER_k
\]

Per capita water use estimates (PCWATER$_k$) for each customer group are defined by user assumption on page 3 of the user interface and are assumed constant over time. By contrast, the number of customers in each residential customer group may vary each year. RESCUST$_{ijk}$ is a function of: (1) the population served by the utility in year i under the baseline infrastructure scenario (POPSERVED$_i$), (2) the percentage of the base served population that falls into customer group k (PERCUST$_k$), and (3) the number of new customers added to or subtracted from customer group k under infrastructure investment scenario j (NEWCUST$_{ijk}$).

\[
RESCUST_{ijk} = (POPSERVED_i \times PERCUST_k) + \sum_{\text{all years} \leq i} NEWCUST_{ijk}
\]

POPSERVED$_i$ and PERCUST$_k$ can both be adjusted through the user interface. NEWCUST$_{ijk}$ cannot be adjusted in the user interface. It is one characteristic of the infrastructure investment scenarios that must be defined in the Excel spreadsheet (Project Info worksheet). (See Figure 19)

**Figure 19:**
Additional population served through new investments

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9 This assumption can be relaxed in the sensitivity analysis after the model has been run.

10 POPSERVED$_i$ is equal to the total population in the base year, times the percentage of the total population served by the utility in the base year, plus the sum of all new customers served by the utility each year in the baseline infrastructure scenario. All three of these variables can be manipulated on page 2 of the user interface. PERCUST$_k$ can be adjusted on page 3.
2. Unadjusted water use estimates for nonresidential customer classes (WATUSENR\textsubscript{ik})

Water use by nonresidential customer classes is assumed constant across investment scenarios, but may increase or decrease over time. The user defines water use by each nonresidential customer class in the base year and also the annual rate of change in water use for each of the classes (USERATE\textsubscript{k}). These two assumptions can be changed in the user interface.

\[
\text{WATUSENR}_{ik} = \text{WATUSENR}_{i-1,k} \times \text{USERATE}_k
\]

3. Adjusted water use estimates by customer class (ADJWATUSER and ADJWATUSENR)

Total unadjusted water use (WATUSE\textsubscript{ik}) is the sum of WATUSERES\textsubscript{ij} and WATUSENON\textsubscript{ij}, in other words the sum of WATUSER\textsubscript{ijk} and WATUSENR\textsubscript{ijk} across all residential and nonresidential customer classes. If WATUSE\textsubscript{ij} is less than or equal to the amount of water available for sale in year I and infrastructure investment scenario j, then the unadjusted water use estimates for each customer class (WATUSER\textsubscript{ijk} and WATUSENR\textsubscript{ijk}) will equal the total adjusted water use estimates for those classes (ADJWATUSER\textsubscript{ijk} and ADJWATUSENR\textsubscript{ijk}). If, however, WATUSE\textsubscript{ij} exceeds the amount of water available for sale, then water use by each customer class must be adjusted for the water shortage situation.
\[
\text{WATDEFICIT}_{ij} = \text{AVAILWAT}_{ij} - \text{WATUSE}_{ij}
\]

The amount of water available for sale in a given year in a particular investment scenario (AVAILWAT\textsubscript{ij}) is a function of the total production capacity in that year and investment scenario and of the technical efficiency of operations (1 - % losses in production and distribution).

\[
\text{AVAILWAT}_{ij} = \text{WATPROD}_{ij} \times \text{TECHEFFIC}_i
\]

Model users can define technical efficiency (TECHEFFIC\textsubscript{i}) in the user interface. Water production in the baseline infrastructure scenario and new water production that will come on line with the new investment projects are defined on the Project Info spreadsheet. Water production in the Project 1 or Project 2 scenario equals water production in the baseline infrastructure investment scenario plus the additional capacity that would be provided either Project 1 or Project 2. For the Project 1 + Project 2 investment scenario, the new capacity from both projects is added to the baseline production capacity.

Model users decide how the water deficit will be allocated across customer classes in the user interface. If the user decides to allocate the entire shortage to one customer class, then \( \text{WATUSER}_{ijk} = \text{ADJWATUSER}_{ijk} \) and \( \text{WATUSENR}_{ijk} = \text{ADJWATUSENR}_{ijk} \) for all customer classes except that one class. If residential class \( k \) absorbs the entire water deficit then \( \text{ADJWATUSER}_{ijk} \) would equal \( \text{WATUSER}_{ijk} \) minus \( \text{WATDEFICIT}_{ij} \). When the user decides instead to spread the water deficit across customer classes, the adjusted water use estimates for each customer class will be equal to the unadjusted water use estimates minus \( \text{WATDEFICIT}_{ij} \) divided by the number of classes to share the shortage.