Five Year (2007-2011) Energy Efficiency Roadmap
National Water Supply & Drainage Board (NWSDB)
Sri Lanka

Annex
Guidelines and Supporting Data

Prepared by:
The Alliance to Save Energy

Submitted to
NWSDB, Sri Lanka
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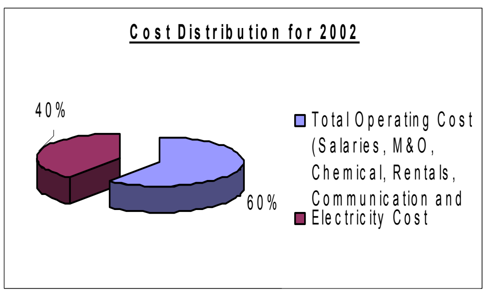
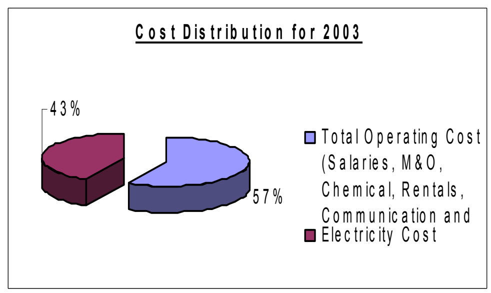
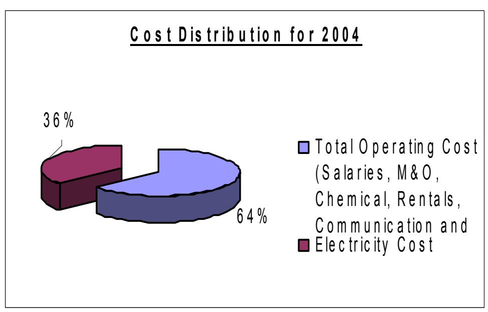
Tables

Table 1: NWSDB Total Operating Costs and Electricity Costs in Sri Lankan Rupees

	2001 – 02	2002 – 03	2003 - 04	2004 - 05
Total Operating Costs (Salaries, Electricity, M&O, Chemical, Rentals, Communication and Others)	2,860,375,681	2,834,131,407	3,454,131,782	3,604,024,192
Electricity Cost	1,135,423,523	1,207,036,638	1,248,338,029	1,217,702,035
Electricity Cost % of total	39.69%	42.59%	36.14%	33.79%







Source: NWSDB ESU

Table 2: List of 287 Pumping Stations

List of Pumping Stations - Energy Data						
S. No.	Name of Installation	Max. Oper. Load/ (kW)	Sanctioned Load/ (kW)	Avg. Monthly Consumption / (kWh)	Power Factor	Age
1						
2						
3						
4						
5						

Table 3: Summary of Energy Consumption by Type of Installation

Type of Installation	Total N	Total Operating Load/ (kW)	Total Monthly Consumption /(kWh)	Average Power Facto
Booster Pumping Stations				
Sewerage Pumping Stations				
Sewerage Treatment Plants				
Water Treatment Plants				
Water Supply (Drinking) Pumping Stations				
Any other information				
TOTAL				

Table 4: NWSDB Plants details - (Energy consumption and Water Production)

S. No	Plant name	Capacity /(m^3/month)	Avg. kWh/ month	SEC / (kWh/m^3)	Cumulative/ kWh
1	Kantale	669167	294000	0.4394	294000
2	Wackwella HL - Old	369000	202476	0.5487	496476
3	Matale HL	331406	166853	0.5035	663329
4	Moratuwa	1036904	166442	0.1605	829771
5	Polonnaruwa	1889303	157442	0.0833	987213
6	Kadduwa	806400	155230	0.1925	1142443
7	Hiriwadunna WSS - TP	184620	150738	0.8165	1293181

8	Uyanwatte	686800	147278	0.2144	1440459
9	Ambalangoda	193550	132568	0.6849	1573027
10	Dodanduwa	55475	132568	2.3897	1705595
11	Baddegama	430100	132568	0.3082	1838163
12	Hikkaduwa	73675	132567	1.7993	1970730
13	Wackwella HL - New	354250	120766	0.3409	2091496
14	Dehiwala	1898166	115905	0.0611	2207401
15	Udu/ Yatinuwara	198508	102180	0.5147	2309581
16	Negombo Production - Bambubuliya TP	608400	101600	0.1670	2411181
17	Negombo Production - Bambubuliya In	657967	90032	0.1368	2501213
18	Ambalantota HL	255601	84598	0.3310	2585811
19	Balakawala	164154	75113	0.4576	2660924
20	Meepitiya WSS	173732	74850	0.4308	2735774
21	Hingurakkgoda	896165	74675	0.0833	2810449
22	Muwagama WSS	198175	73221	0.3695	2883670
23	Malembada	856000	69009	0.0806	2952679
24	Maharagama	503424	63826	0.1268	3016505
25	Avissawella	161581	61098	0.3781	3077603
26	Amugoda Intake	302000	49245	0.1631	3126848
27	Marassana	57662	48890	0.8479	3175738
28	Kataragama	108840	47634	0.4377	3223372
29	Kattakaduwa	85211	45591	0.5350	3268963
30	Issadeen Town	158250	45163	0.2854	3314126
31	Ambalantota Bolan PH (Intake)		37402	0.0000	3351528
32	Matale LL	344607	36924	0.1071	3388452
33	Balangoda WSS - Welliharanawa	90125	36840	0.4088	3425292
34	Anuradhapura New Town	473497	36138	0.0763	3461430
35	Kirindi Oya LL		35887	0.0000	3497317
36	Sacred City	92152	34030	0.3693	3531347
37	Baddegama LL	355425	33123	0.0932	3564470
38	Tangalle	99341	30860	0.3106	3595330
39	Balagalla	112150	29293	0.2612	3624623
40	Kananke	99518	27963	0.2810	3652586
41	Kirindi Oya HL	134228	27116	0.2020	3679702
42	Atigala Mawathe		26364	0.0000	3706066
43	Udawalawa WSS	68575	25795	0.3762	3731861
44	Makumbura	75765	22990	0.3034	3754851
45	Palanwatte	116414	22989	0.1975	3777840
46	Polgolla/ Madawala	139048	20170	0.1451	3798010
47	Suriyawewa		19938	0.0000	3817948
48	Mihintale	28186	19567	0.6942	3837515
49	Nadugala	121050	19081	0.1576	3856596
50	Embilipitiya HLT	156032	18985	0.1217	3875581
51	Embilipitiya WSS	151275	18153	0.1200	3893734
52	Kekirawa	22786	16009	0.7026	3909743
53	Beliattha - Ambala HL	63089	15747	0.2496	3925490
54	Mirihella PH	3139	15279	4.8675	3940769
55	Hallala	85996	14620	0.1700	3955389
56	Athurugiriya	31958	13483	0.4219	3968872
57	Ambalantota Old PH (Intake)		13456	0.0000	3982328
58	Angunakolapelessa	52426	13306	0.2538	3995634
59	Bakamoona	136393	11358	0.0833	4006992
60	Galawilawatte	59009	8907	0.1509	4015899

61	Panadura		8666	0.0000	4024565
62	Thambuttegama/ Eppawala	32473	8644	0.2662	4033209
63	Medawachchiya	13527	6936	0.5128	4040145
64	Walasmulla	13854	6588	0.4755	4046733
65	Kahatagasdigiliya/ Horowpathana	16291	6494	0.3986	4053227
66	Beralihala		6408	0.0000	4059635
67	Dembarawewa	37332	6204	0.1662	4065839
68	Tissamaharamaya		5477	0.0000	4071316
69	Homagama Old	42107	5083	0.1207	4076399
70	Beliattha - Kudaheela		5051	0.0000	4081450
71	Galnewa - Bulnewa	22443	4906	0.2186	4086356
72	Hapugala	203108	3989	0.0196	4090345
73	Pitigala	5035	3749	0.7446	4094094
74	Rukmalgama	19533	3430	0.1756	4097524
75	Padaviya	9763	3247	0.3326	4100771
76	Dimbulagala	28712	2393	0.0833	4103164
77	Ridiyagama	3889	2161	0.5557	4105325
78	Kebithigollewa	6539	2151	0.3289	4107476
79	Kadugannawa HL	36039	1625	0.0451	4109101
80	Mattala		1503	0.0000	4110604
81	Maradankadawala	4214	1382	0.3280	4111986
82	Balapitiya	3045	1101	0.3616	4113087
83	Elpitiya	13044	933	0.0715	4114020
84	Habarana	4979	415	0.0834	4114435
85	Modarawila		409	0.0000	4114844
86	Labugama WTP	1155833		0.0000	4114844
87	Colombo City	7725495		0.0000	4114844
88	Kadugannawa LL	62090		0.0000	4114844
89	Hiriwadunna WSS - PH	44481		0.0000	4114844

Table 5: High Priority Booster Pumping Stations (BPS) for EE Implementation

Booster Pumping Stations (BPS) for Energy Efficiency Implementation

S.No	Name of Installation	Max. Oper. Load / (kW)	Sanctioned Load / (kW)	Avg. Monthly Consumption/ (kWh)	Power Factor	Age
1						
2						
3						
4						
5						

Table 6: High Priority Sewerage Pumping Stations (SPS) for EE Implementation

Sewerage Pumping Stations (SPS) for Energy Efficiency Implementation

S.No	Name of Installation	Max. Oper. Load / (kW)	Sanctioned Load / (kW)	Avg. Monthly Consumption/ (kWh)	Power Factor	Age
1						
2						
3						
4						
5						

Table 7: High Priority Sewerage Treatment Plants (STP) for EE Implementation

Sewerage Treatment Plants (STP) for Energy Efficiency Implementation

S.No	Name of Installation	Max. Oper. Load / (kW)	Sanctioned Load (kW)	Avg. Monthly Consumption/ (kWh)	Power Factor	Age
1						
2						
3						
4						
5						

Table 8: High Priority Water Treatment Plants (WTP) for EE Implementation

Water Treatment Plants for Energy Efficiency Implementation

S.No	Name of Installation	Max. Oper. Load / (kW)	Sanctioned Load / (kW)	Avg. Monthly Consumption/ (kWh)	Power Factor	Age
1						
2						
3						
4						
5						

Table 9: High Priority Water Supply (Drinking) Stations for EE Implementation

Water Supply (Drinking) Stations for Energy Efficiency Implementation

S.No	Name of Installation	Max. Oper. Load / (kW)	Sanctioned Load / (kW)	Avg. Monthly Consumption/ (kWh)	Power Factor	Age
1						
2						
3						
4						
5						

Table 10: Electricity and Water Production Analysis at Ambatale WPP

Month	Water Production/ million m^3	kWh/ m^3	kVA/ (1000xm^3)
Sep-04	15.32	0.3533	0.6005
Oct-04	15.96	0.3514	0.5639
Nov-04	15.46	0.2921	0.5757
Dec-04	15.98	0.3902	0.5632
Jan-05	15.95	0.3117	0.5643
Feb-05	14.43	0.3590	0.6306
Mar-05	15.69	0.3353	0.5736
Apr-05	15.31	0.2786	0.4964
May-05	15.98	0.2831	0.4881
Jun-05	18.43	0.2843	0.4232
Jul-05	19.01	0.2413	0.3998
Aug-05	19.38	0.2361	0.3870

Sep-05	18.87	0.2552	0.4028
Oct-05	19.47	0.2078	0.3852
Nov-05	18.73	0.2478	0.4004
Dec-05	19.39	0.2394	0.3816
Jan-06	19.52	0.2380	0.3791
Feb-06	17.8	0.2442	0.4157
Mar-06	19.79	0.2654	0.3739
Apr-06	19.06	0.2035	0.3882
May-06	19.9	0.2453	0.3719
Jun-06	19	0.2267	0.3895

Table 11: Data Collection format – Monthly Operational Data Sheet

MONTHLY OPERATIONAL DATA SHEET

PUMPING STATION : ………………………………….REGION:…………………..……… SCHEME: ………….………………

STATION IN-CHARGE NAME:…………………………………………………………………………………………

CONTACT NUMBERS :…………….……………No.OF NEW SERVICE CONNECTIONS: ……………………………………

MONTH :………………………………………………………… YEAR :………………………………….

	kWh/mo (Average)	kVA/mo (Maximum)	Water Produc MLD	Total Operating Hours per month					
				Pump1	Pump2	Pump3	Pump4	Pump5	Pump6
Previous month data									
Current month data									
Difference									

List down the implementations and modifications for savings:

Annex 2
Investment Grade Audit (IGA)

Steps Involved in an Investment Grade Energy Audit (IGA) For Water and Waste Water EE Projects:

An Investment Grade Audit (IGA) is the first step in the path to improved energy efficiency. This section presents information on all steps involved in preparing and implementing Investment Grade Audits (IGAs) of municipal energy and water systems. The technical details of conducting investment grade audits are given in the following section.

As the name implies, an Investment Grade Energy Audit is the process of conducting an energy audit to identify efficiency opportunities, and translating the technical findings into financial terms to present it as a bankable project capable of securing a loan. The IGA report contains comprehensive information related to energy use by the municipality and provides clarity on the baseline and verifiability of savings once the project is implemented. The term *ESCO (Energy Service Company)* is used in this document to indicate the audit conductor even though this firm or individual is not necessarily an Energy Service Company.

1 Discussions with Key Facility Personnel

The first step of an IGA is a set of initial discussions between the ESCO and key personnel such as ESU and NWSDB engineers' in-charge of the pumping stations, and pump operators to explain the objectives of the project, the benefits of energy efficiency, and the approach that will be used in conducting the audit. The purpose of these meetings is to ensure that the decision makers thoroughly understand and support the process, and that relevant facility staff have an adequate understanding of the process since they will be providing the ESCO with data and specifications about the facility essential to the audit.

2. Site Visits

Next the ESCO should visit all facilities involved in the project (potentially encompassing the entire municipality) to ascertain the availability of data and system complexity, formulate a data collection strategy, and other issues. This process will assist the consultant in identifying the proper personnel at different facilities to coordinate the audit. Submitting a report to the municipality after the site visits will ensure that the municipal participants are informed and better able to assist as needed.

3. Preliminary Data Collection

The ESCO will map the existing facilities targeted by the audit — such as water pumping stations, the water distribution system, electrical distribution system, and buildings — to better understand the facilities. NWSDB can expedite the process by providing all available system and process maps. The mapping will help the ESCO identify potential projects. Aside from the use of maps for the audit itself, the municipality will benefit from the information in those cases where process layouts were not available.

The ESCO then designs "data format sheets" for recording monthly energy consumption and operating data for the last three years. Historical data is generally accepted as the previous three years of energy bills for a given facility. Analysis of the data helps the ESCO to identify systems for detailed measurement and monitoring. There is also a preliminary walk-through audit of the facilities to identify those areas where detailed measurements have to be taken during the full audit.

4. Steps for Conducting the Detailed Audit

A detailed audit includes data collection, measurements of the systems, analysis of the historical and measured data, and detailed energy savings calculations for suggested projects. The ESCO not only analyzes the performance of individual equipment, but evaluates the complete system — for example valves, pumps, the pressure drop in pipelines, and the electrical distribution system — in order to obtain a comprehensive efficiency solution that captures all energy efficiency opportunities, not just the more obvious ones.

4.1 List proposed efficiency projects

The detailed energy audit carried out at the various facilities will help identify energy efficiency measures. The measures that have the best technical and economic potential will be further developed into saving projects that should be listed in the report.

4.2 Steering committee

The ESU should establish a local steering committee to assist in monitoring the work of the ESCO/consultant and render guidance for the entire project work. The team leader from the ESCO can then meet with the committee on a weekly or biweekly basis to review progress to facilitate the completion of the project in a timely manner and eliminate discrepancies at later stages. The steering committee should consist of the following personnel:

- Representative from ESU
- Chief engineer
- Representative from the design department
- Representative from the planning department
- Other concerned senior personnel from the relevant department

4.3 Develop a set of potential efficiency projects

The ESCO develops a set of potential efficiency projects for consideration, in consultation with the steering committee. An investment grade evaluation conducted on each that includes the following:

- ✓ Description of the baseline situation (e.g., losses from a water supply system),
- ✓ Project design, including basic engineering,
- ✓ Technical constraint analysis,
- ✓ Project financials,
- ✓ Baseline calculation,
- ✓ Options for monitoring and verification,
- ✓ Assessment of potential technical and financial risk and a risk mitigation plan.

The ***baseline*** of energy use (and water as appropriate) is calculated from all relevant information, such as operating conditions, measurements of various system equipment, log book trends, historical data, and any previous test reports on the existing operating conditions.

The ***project financials*** (cost benefit and financial analysis) are calculated by the ESCO using the detailed cost estimates obtained for all equipment and the projected saving rates. This allows the potential projects to be classified according to their cost-effectiveness. Cash flow considerations should also be taken into account since this will determine the amount that needs to be financed by a commercial bank or other local/international financial institutions. From the financial analysis, the ESCO develops an action plan by prioritizing the projects based on so called "ABC-analysis" where activities are classified according to specific performance criteria, both technical and financial. "A" corresponds to priority projects; "B" corresponds to less important projects; and "C" classifies relatively unimportant ones.

Monitoring and Verification involves the measurement of parameters in accordance to standard engineering protocols, codes & practices, at a predefined periodicity and term. M&V on efficiency projects are to be conducted in accordance with the norms of the International Performance Measurement and Verification Protocol (IPMVP), and considering operating conditions specific to country. Various M&V plans consistent with IPMVP should be analyzed to select the best option for tracking savings. Since savings are calculated relative to the baseline, the choice of M&V protocol needs to be consistent with the calculation of the baseline. As needed, different M&V protocols may be chosen for different individual projects.

5. The Audit Report

The audit report is not only the foundation for the performance contract, but is the key document used by financial institutions to assess the financial viability of the project. The minimum content of the report should be as follows:

Executive Summary: Provides brief description of the facilities covered, measures evaluated, analysis methodology, results and a summary table presenting the cost and savings estimates for each recommended measure. It also includes a summary of the recommended measures and costs as well as the financial indicators of the project.

Background: More extensive background about the municipality and project.

*Facility Description**:*** Details of the existing facilities targeted, such as water treatment, supply and distribution systems, and electrical distribution systems, sewage treatment and handling systems and buildings.

*Energy Scenario**:*** Energy consumption details of all facilities included in the audit and their energy sources.

Inventories: Inventory of all relevant systems, including pumping, lighting, water treatment, supply and distribution, and other systems.

Baseline Parameters and Adjustments: Methodology followed in establishing the baseline parameters and the criteria to be followed in adjusting it. Provide the all baseline parameters and the calculation procedure in an annex.

Data Collection: List the various types of data collected and their sources. Include the data in the annex.

System Mapping: Describe the methodology followed for system mapping and include the maps in the annex.

List of Potential Projects: A list of all identified measures with estimates of the savings and payback periods on investments, and a summary of the steering committee meeting decision selecting those projects chosen for further development.

Details of the Approved Projects: Each of the approved projects should be discussed in the report along with the following information:

- EXISTING SITUATION: Describe the existing situation, including operational practices, associated with the planned efficiency improvements, including a pictorial representation.
- PROPOSAL: Provide a background of the opportunity for improvements and discuss the proposed retrofits and modifications necessary for achieving the savings and the cost-benefit analysis associated with them. Provide a list of possible vendors/suppliers for the equipment and the detailed energy saving calculations in the annex.
- BASELINE PARAMETERS: Establish the baseline parameters for each project and any adjustments that might be required over the course of the project, for example due to a change in demand.
- M&V PLAN: Develop an M&V plan for the project.
- RISKS AND THEIR MITIGATION: Discuss the possible risks in implementing the project and suggest mitigation plans.

Training of NWSDB staff: Based on discussions with engineers and other relevant staff the report should include a proposal for short- and-long term training program that the ESCO will conduct for facility personnel. Training will typically cover mapping, methods for identifying the opportunities for energy efficiency, and implementation of efficiency measures.

Guidelines On The "Technical Scopes Of Work" For Water And Waste Water Systems Energy Efficiency Investment Grade Audits

The Investment Grade Audit documents current technical conditions, recommends energy saving projects, and presents the technical descriptions of the potential energy efficiency measures along with an assessment of the expected energy, water and cost savings. This chapter provides guidance on how to perform a detailed IGA. At a minimum, the technical scope of work performed on an IGA should include the following:

- An energy performance evaluation and system optimization study of all facilities in the NWSDB targeted for improvements.
- Efficiency tests on the major energy consuming equipment, recommendations for replacing and retrofitting those that are inefficient, and calculations of projected benefits.
- Suggestions for improvements to operating and maintenance practices.
- Financial details on the investment required, including materials and potential service providers, expected savings, and payback period.
- A list of the energy efficiency measures prioritized according to the highest rate of return on investment and organized into short, medium and long term categories. (Payback periods for long term measures should be three years or less.)
- A review of any existing metering and billing system and suggestions for a new or improved one.
- A risk analysis, technical & financial, including the mechanisms that need to be put in place to manage and control risks.
- A suggested M&V plan.

1. **Detailed Audit of Individual Systems to Create List of Potential Projects**
    - The major energy loads in water utilities are typically the water pumping systems, sewage treatment and handling, and electricity distribution. Buildings such as offices also contribute to the high NWSDB energy bills.

SYSTEM MAPPING

In all cases, visit the systems and sketch the area map of each. If the network diagrams for these systems are available from the NWSDB, revalidate them.

Water supply and distribution, sewage treatment and handling

If the network diagrams are not available from the NWSDB, map the system in the following manner, including the distribution networks, pump design details, and suction discharge pipe lines:

- ✓ Layout the systems including the intake arrangements, clarifiers, and filters, indicating their sizes, capacities, connected loads, etc.
- ✓ Layout the pumping stations including the location of the pumps, their design details, suction and discharge pipe sizes, and routing.
- ✓ Sketch the water distribution system indicating pipe lines, pipe line sizes, branching points, approximate lengths, bends, and valves up to the overhead tank or to the main end user points, in case of direct pumping.
- ✓ Identify the points where pressure measurements and flow measurements are to be done.

DATA COLLECTION

Water supply and distribution, sewage treatment and handling

Data to be collected should include but not limited to the following:

- ✓ Water sources of the NWSDB.
- ✓ If the source is outside the NWSDB:
  - Number and locations of the main water sources
  - Distance between the main source and the NWSDB storage facility.
- ✓ Number and locations of pumping stations in the NWSDB.
- ✓ For all the pumps at the source, pumping stations throughout the system, and sewage treatment and handling facilities:
  - Pump design details
  - Operation hours of the individual pumps on a daily basis for the past 12 months
  - Quantity pumped, if available
  - Operational details including flow, head, power and power parameters.
- ✓ Quantity pumped from each of the stations on a daily basis for the past 36 months.
- ✓ Electricity bills of the individual pumping stations for the past 36 months.
- ✓ Maintenance expenses of the individual pumping stations for the past 12 months.
- ✓ Number of overhead tanks connected with each of the pumping stations or the number of domestic, public and commercial connections in each of the pumping stations.
- ✓ Water distribution system and sewage collection system single line diagram, if available.
- ✓ Sizes of the pipe lines in the distribution system, including for the source water and sewage systems, if any.
- ✓ Population of the municipality on an annual basis for the past 3 years. If not available, collect the census details of the previous census and derive the population.
- ✓ Ground water levels at various seasons of the year for the past 3 years, if the pumping is through bore wells.
- ✓ Reservoir levels for the different seasons.
- ✓ Sewage storage levels for the different seasons for the past few years.

Preparatory Work for Measurements

WATER SUPPLY AND DISTRIBUTION, SEWAGE TREATMENT AND HANDLING

- ✓ Prepare data sheets for recording pressure measurement. Sampling points should be at certain strategic points that will not be a hindrance to the public. The purpose of this sampling is to help:
    - Evaluate pump performance
    - Evaluate the performance of an entire pumping system
    - Establish the pressure profile along the pipelines
    - Establish the application of booster pumps at certain strategic locations
    - Measure flow in the major branch lines.
- ✓ Prepare data sheets to capture operational details of the pumps in more detail than that in the log book.

MEASUREMENTS

Water supply and distribution, sewage treatment and handling

Measurements must be done for all the pumps individually as well as for the whole operating system to establish the performance of both. The following is the minimum that must be measured:

- ✓ Flow and head measurements of individual pumps at various intervals. If the pumps are running continuously during daytime and evening hours measure at three hour intervals. If the pumps are running at pre-specified times, at least four readings are to be taken at different time intervals.
- ✓ Flow and head measurements of the entire system as described above.
- ✓ Power measurement using the power analyzer for those pumps for which the flow measurements are made simultaneously.
- ✓ Electrical parameters of all the pumps.
- ✓ Power parameters of the pumping station continuously for 24 hours.
- ✓ Pressure recordings at the pumping station every half hour for 24 hours
- ✓ Other measurements as needed to characterize the system.

DATA ANALYSIS

Conduct the following analysis to calculate the baseline of the entire project as well as for individual projects making up the whole:

- Historical data analysis to establish the power consumption trends.
- Analyze design parameters and actual operational parameters with a view to identify problems.
- Analyze pressure and voltage profiles with a view to identify losses.

- Analyze distribution network with a view to identify system resistance and whether pipes and cables are the correct size.
- Evaluate the performance of the individual pumps, or combination of pumps in case of parallel operation, and the pumping system as whole, including transformers, lighting system.

CHOOSING PROJECTS FROM LIST OF POTENTIAL PROJECTS

Based on the analysis, the Consultant make a list of projects with good potential for saving energy (and water if applicable) that includes the following information:

- Configuration of the existing system
- Configuration of the proposed system
- Estimate of the energy savings and other benefits
- Estimate of the investment and its payback period
- Retrofit requirements

The potential projects are then discussed at the steering committee appointed by the NWSDB, which selects a set of projects to develop fully. It is suggested that the ESCO and steering committee meet every weekly or two thereafter to help the committee monitor progress.

Finalizing a Set of Approved Projects

To more fully develop the short list of projects approved by the steering committee, conduct a more robust data collection and analysis to ensure the technical viability of each project, and if this analysis is favorable proceed to design the concept and configuration, including the life of the project and technical constraints. Once the ESCO develops the short list of projects more fully, they are discussed in detail with the steering committee, with their suggestions for modification incorporated appropriately. The finalized projects are discussed at length in the audit report.

Three key aspects of the detailed audit at this stage are the financial analysis, risk assessment, and baseline calculations, discussed in more detail below.

Detailed Financial Analysis

Calculate the financial aspects of each individual project as well as that of the entire project, determining the costs (on a net present value, NPV, basis), marginal cost for each unit of savings (at the time the audit is performed), the simple payback period from the savings, and return on investment. The financial analysis includes:

- Anticipated adjustments to the baseline to reflect changing conditions at the facilities compared to the historic baseline. Factor in any anticipated deterioration in annual savings through the life of the project due to the age of the equipment.

- Costs for engineering, design, materials and operations, including:
    - Contractor and vendor estimates
    - Contingency costs
    - Construction management fees
    - Commissioning costs
    - Taxes & duties
    - Initial training costs
    - Annual service fees including M&V, maintenance, and ongoing training.
- If the project will be financed by a commercial bank, a cash flow analysis that includes an internal rate of return, debt service coverage ratio, and cash accruals.

Another useful financial analysis tool is a Sensitivity Analysis, where key variables in the cash flow are tested to determine how sensitive the project's NPV, payback period, and IRR are to changes in costs such as electricity, labor and fuel. It is useful because it can highlight variables that pose a significant risk to the project if they have a high probability of occurring.

Risk Assessment and Mitigation Plan

The scope for the risk assessment and risk mitigation plan includes but is not limited to the following:

- **Design and Construction Risks**
    - Baseline Establishment
    - Technical Efficacy
    - Completion risk
    - Delay in construction
    - Conformance to standards and government approvals
- **Performance Risk**
    - Equipment performance
    - Longevity of energy savings
    - Accuracy of savings estimates
    - M&V Risk
    - Operational changes
    - Capacity of facility (i.e., non-ESCO) personnel
- **Financial, Economic and Regulatory Risk**
    - Cost overrun – initial and operating
    - Interest rate risk
    - Foreign exchange risk
    - Regulatory – changes in laws relating to tax concessions etc
    - Financing
    - Financial Disaster of any of the project Holder

- **Market Risk** (energy price risk due for example to changes in tariffs)
- **Credit Risk (**creditworthiness of the entity — NWSDB or ESCO — getting the loan)
- **Environmental Risk**
  - Insurance coverage in case of an environmental hazard or accident
  - New (or newly enforced) environmental standards
- **Force Majeure (**natural disaster during the design and construction)

A Risk Matrix can be used for this task that lists the following variables in a table:

- ✓ Classification or type of risk
- ✓ Reason for the risk
- ✓ Risk mitigation measure adopted
- ✓ Consequences for the lender
- ✓ Consequences for the investor.

BASELINE CALCULATIONS AND ADJUSTMENTS

Baseline parameters for entire project

Base line parameters for the entire water utility, or the sum of those systems in it which are being targeted, are established based on the previous three years of energy bills (calculated as an average on a monthly basis). While establishing this, care should be taken to identify any major loads that are introduced or deleted during the period under consideration. Three years is the standard because NWSDB energy bills are directly correlation with seasonal variations and operating practices. The base line may be determined by comparing the three-year monthly average with that of the immediate past 12 months and taking the higher of the two.

Energy baseline parameters for individual systems

The energy baseline has to include the following parameters, wherever applicable, to avoid ambiguity during M&V:

- Historical monthly averages (over the past 36 or 12 months, whichever is higher) for:
  - ✓ Hours of operation of pumps in each pumping station (hours per day)
  - ✓ Power consumption of pumping stations
  - ✓ Specific power consumption of each pumping stations (in kWh per million liters per day, MLD, of water pumped)
  - ✓ Pumping station system efficiency developed from historical data and the measurements pertaining to pumps during the audit
  - ✓ Specific maintenance expenses (per MLD of water pumped)

- ✓ Levels for ground water, reservoirs and storage at each pumping station
- ✓ Power failure electricity board (hours per month)
- ✓ Inventory of different types of lamps to be replaced
- ✓ Individual pump performance

Typical baseline parameters and their measurement periods are summarized in Table 1 below. In all cases data is collected from a mixture of spot measurements, energy bills, log books, and other historical data. The project host (NWSDB) and ESCO will agree upon the measurement criteria and the duration of measurement.

Table 12. Baselines Parameters to be Measured

	Parameters to be measured	Measurement Period
Water pumping & water distribution systems	▪ Water flow (m^3/hr) from each pumping station ▪ Pump discharge pressure (kg/cm^2) ▪ Header discharge pressure (kg/cm^2) ▪ Pressure at various points in distribution system (kg/cm^2) ▪ Ground water level (m) (in the case of bore wells and submersible pumps) ▪ Reservoir levels (m) ▪ Motor kWh, kVAh, pf, frequency and speed. ▪ Power consumption (kW) of individual pumps in the system ▪ Operating hours per day of each pump ▪ Monthly electricity bills for the pumping station (if available) ▪ Cost of water	Flow, pressure & power measurements of individual pumps at various intervals. Measurements to be done at 3 hours interval, if the pumps are running continuously during daytime and evening hours. If the pumps are running at pre specified timings, at least 4 readings are to be taken at different time intervals. Ground water level, reservoir levels and electricity bills are read monthly.
Sewage treatment & handling systems	• Flow (cum/hr) from each pumping station • Pump discharge pressure (kg/cm2) • Header discharge pressure (kg/cm2) • Pressure at various points in the distribution system (kg/cm2) • Reservoir levels (m) • Motor KWh, KVAh, pf, frequency and speed. • Power consumption (KW) of individual pumps in the system • Operating hours (hrs) of each pump per day Monthly electricity bills for the pumping station (if available)	Flow, pressure and power measurements of individual pumps at various intervals. Measurements to be done at 3 hour intervals if the pumps are running continuously. If the pumps are running at pre-specified times, at least four readings are to be taken at different time intervals. Reservoir levels and electricity bills read monthly.

Electrical distribution systems	• Measurement of KWh, KVA, pf at source end and supply end simultaneously • Monthly electricity bills for the electrical distribution system (if available)	Power measurements of individual feeder at various intervals. Measured continually for few days.

Baseline adjustments

Adjustments to the baseline are made when post-implementation conditions in energy use change relative to the original baseline conditions documented in the M&V plan. It is important to have a method of tracking and reporting changes to the baseline conditions. Many factors affect the performance of the equipment and system over time and thereby the achievement of savings over the course of the project. Parameters that are predictable and measurable can be used for routine adjustments. Such adjustments reduce the variability in reported savings and provide a greater degree of certainty in reported savings. At times unpredictable changes to the parameters, such as unexpected changes in use, may require non-routine adjustments to the baseline in the future. Therefore the M&V plan must take into account predictable changes to the baseline, such as growth in the number of household water connections, the ability of changes to be measured, and the likely impact of changes. The most common factors are summarized in Table 2 below. The ESCO and the project host must agree on how such changes will be factored into baseline adjustments over the course of the project.

Table 13: Parameters Likely to Change over the Course of the Project, Requiring Adjustments to the Baseline

Parameter	Unit	How Addressed
Change in the usage pattern	kWh	The expected changes in usage pattern needs to be established in the performance contract
Seasonal changes in the reservoir levels or ground water levels	M	Monthly variations need to be obtained
Seasonal and daily changes in ambient weather conditions	^{o}C	Hourly and daily ambient dry bulb and wet bulb temperatures to be obtained
Power quality	kWh	Continuous measurement of power parameters for 24 hours over 5 to 10 days to establish the power quality variations.
Capacity addition – future demand changes	m^3/hr, kWh	Any addition or deletion of the loads should be recorded by NWSDB and shared with ESCO
Equipment use by operators in accordance with specifications	-	Establish a system of communication and measurability to ensure proper operation.
Equipment deterioration	-	Has to be taken into account (book value depreciation as per standard accounting practice)
Equipment life	Years	Provisions are to be made in the budgets for replacements on completion of service life during the service period

Calculating Savings

In addition to agreeing upon the baseline and allowable adjustments, both NWSDB and the ESCOs must agree on how to calculate the energy and cost savings resulting from the project. Once the work has been done to determine the baseline and adjustments, the calculation of energy savings is done in a straight forward manner as:

Energy Saved = Baseline – Current ± Adjustments

Where:

- *Energy Saved* is the energy saved over a period of time from project start to a set point in time
- *Baseline* is the baseline energy consumption (kWh)
- *Current* is the current energy consumption (determined by metering or the utility energy bill)
- *Adjustments* are any adjustments, positive or negative, that need to be made to the baseline to bring energy use at the current point in time to the same set of conditions as the baseline set.

In order to calculate cost savings from the energy savings, the parties must agree on how to handle energy price fluctuations because the resulting amount should be a function only of the efficiency measures, not fluctuating energy costs. One method is to agree on a set price, either one defined upfront in the performance contract, or a formula or definition for calculating one (e.g., the average monthly energy cost over the time period being examined).

Annex 3

PUMPING SYSTEM DATA QUESTIONNAIRE

Station Name:

Installed Capacity, MLD :

Operating Capacity, MLD :

Contract Demand of the Plant, kVA :

Annual Energy Consumption, hundred thousand kWh :

Annual Energy Cost, LKR hundred thousand :

No. of pumps in the station :

Brief system diagram of the water supply :

Station Details

a. Name and Location (Place)

b. Station in charge, address & contact number for technical details

c. Year of Establishment

Source of Water

a. Water source is from (Surface/Underground)

b. Details of installation

Pump House Details

a. Number of Pumps with rated flow, head and power

b. Type of Pump

c. Working hours per day

PUMP DETAILS

Description	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5
Pump I D Code					
Application					
Type of Pump					
Manufacturer's Name					
Year of Installation					
Rated Flow (m^3/h)					
Rated Head, meter					
Rated Pump Power (kW)					
Rated Pump Efficiency (%)					
Rated motor KW					

ENERGY CONSUMPTION DATA

Contract Demand (kVA) :

Minimum billing demand (kVA) :

Minimum power factor to be maintained :

Power (kWh) charges :

kVA Maximum demand charges :

Any P.F. penalties paid :

Any other details, if any :

SUB-STATION DETAILS

Transformer Details

Description	TRF-1	TRF-2	TRF-3	TRF-4
Transformer ID code				
Transformer Application				
Rated kVA capacity				
Rated Pry / Sec Volts				
No. of f taps				
Tap changing (On load/Off load) (Auto/Manual)				