Demand-Side Management Project
South Pacific Island States

REPORT ON CURRENT DSM ACTIVITIES AND UTILITY DATA
UTILITY: ELECTRIC POWER CORPORATION (EPC)

prepared for

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EXECUTIVE SUMMARY

Introduction

The United Nations Development Programme (UNDP) funded a project titled “Support to the Pacific Islands Power Sector” (RAS/92/363) which was implemented through the Energy Division of the South Pacific Forum Secretariat (ForSec) from 1993 to 1996. Building regional capability in all aspects of Demand-side Management (DSM) program design and implementation was one of the key objectives of the project. Under the UNDP project a total of 10 Pacific Island electric utilities participated in a DSM Potential Study. Emphasis was given to capability building in DSM data gathering, analysis and program planning.

The current DSM Project, approved by member countries of SOPAC and the Secretariat for the Pacific Community (SPC) and included in the 1999 Regional Energy Program Design Report, aims to follow-up on the recommendations on the initial UNDP DSM Program. This includes assisting participating utilities in the implementation of pilot DSM projects and subsequent refinement into full-scale programs that benefit the utility, consumer and society as a whole.

This report summarises the DSM potential, relevant activities and utility data for the Electric Power Corporation.

Utility Overview

A wholly government-owned utility, the Electric Power Corporation (EPC) was established under the Electricity Power Corporation Act in 1972 and administered by a seven-member board headed by the Minister of Public Works. Located in Apia, EPC is responsible for the generation, transmission, and distribution of electricity and caters both for the private and commercial sectors, including the rural areas of Samoa.

As of August 1995, the total installed capacity of EPC amounts to 25.9 MW, de-rated to 22.1 MW, generated mostly (52%) from hydropower. About 34% of which is produced from run-of-river and 18% by storage hydropower. The remaining 48% is produced by diesel generation sets.

Samoa consists of a group of volcanic islands situated east of International Dateline, between Hawaii and New Zealand. Its main islands Upolu and Savai’i plus Apolima, Monono and five uninhabited islets, has a total land area of 2,935 square meters. About 95% of EPC’s capacity is supplied to the main islands, Upolu and Savai’i with overall household electrification of 90%.

DSM Activities

The expansion and refinement of the DSM activities into full-scale implementation is prioritized as government commitment to provide benefits to EPC, customers, and the national economy.

As a result of recent significant growth in electricity demand, which exceeds the overall hydro capacity, the use of thermal generation (diesel) for meeting system demands has been predominant. The current tariffs do not reflect the current generation mix and as a result, reducing diesel generation has become a priority.
EPC has undertaken an aggressive campaign to reduce demand and has focused on its top 50 industrial and commercial customers. EPC staff has been providing advice to customers on energy efficiency and efficient technologies.

**DSM Options**

Preliminary analysis of EPC’s current system load profile indicates commercial sector driven peaking load in the weekdays and a residential sector driven peak load on the weekends. In addition, the weekday profile shows an evening peak caused by the residential sector.

In order to meet EPC’s objective of reducing thermal generation, peak clipping and valley filling appear to be the DSM concepts offering the maximum benefits. These could be achieved by the following programs:

1. Base Load Reduction in the Industrial Sector
2. Energy Efficiency and Management Program in the Commercial Sector
3. Efficient Lighting and Appliances Program in the Residential Sector.
1 PROJECT BACKGROUND

The United Nations Development Programme (UNDP) funded a project titled “Support to the Pacific Islands Power Sector” (RAS/92/363) which was implemented through the Energy Division of the South Pacific Forum Secretariat (ForSec) from 1993 to 1996. This project was a part of the Core Regional Energy Program administered by ForSec. The project was implemented with the support of the Pacific Power Association (PPA) – a newly formed association of electric utilities in the South Pacific region and utility service providers. Building regional capability in all aspects of Demand-side Management (DSM) program design and implementation was one of the key objectives of the project. In January 1998, in accord with the desire and direction of the Forum Leaders, the Regional Energy Program was relocated at the South Pacific Applied Geoscience Commission (SOPAC).

Under the UNDP DSM Program a total of 10 Pacific Island electric utilities participated in a DSM Potential Study. Emphasis was given to capability building in DSM data gathering, analysis and program planning. The key activities of the project included:

- One Week Intensive DSM Workshop
- Utility-specific Customer Data Gathering
- DSM Program Planning Workshop
- DSM Program Design and Analysis
- Production of a DSM Manual

One of the objectives of the Regional Energy Program is the reduction in the demand for electricity and the use of fossil fuels for electricity generation in conjunction with the adoption of renewable energy technologies where financially and economically feasible. Most Pacific Islands (with the exception of PNG, Fiji, Solomon Islands and Samoa) are primarily dependent on imported petroleum products for electricity generation. In addition, lack of importance placed on energy efficiency and constraints due to economies of scale has compounded the situation.

The current DSM Project, approved by member countries of SOPAC and the Secretariat for the Pacific Community (SPC) and included in the 1999 Regional Energy Program Design Report, aims to follow-up on the recommendations on the initial UNDP DSM Program. This includes assisting participating utilities in the implementation of pilot DSM projects and subsequent refinement into full-scale programs that benefit the utility, consumer and society as a whole.

Although the contribution to overall greenhouse gas (GHG) emissions is miniscule, the smaller Pacific Island states are the most vulnerable to impacts of climate change. The energy sector has been targeted as the sector that provides the best opportunities for the reduction of GHG emissions considering electricity generation is primarily from fossil fuels. There is a commitment by the Pacific Islands states to comply with the spirit of the Kyoto Protocol in reducing GHG emissions although they are not obligated by any emission limits.
1.1 Project Objectives

Pacific Island utilities are adopting the concepts of Integrated Resource Planning (IRP) where supply and demand side options are considered in future least-cost supply planning scenarios. Hence, the evaluation of achievable DSM potential is of significant importance in future capacity planning. Since the UNDP Power Sector Project was completed in August 1996, DSM activities have not been pursued in any coordinated manner and have been a low priority activity in most utilities in the region.

The aim of this project is to re-establish and continue the development of a DSM Program for the electric power utilities in the region with benefits flowing to all customer sectors – Residential, Commercial and Industrial. In meeting this objective the following are proposed:

- Determination the current status of DSM activities within electric utilities of SOPAC Member Countries;
- Determination of the most appropriate technologies and the methodology for implementation of DSM in the region;
- Conduct of detailed design of appropriate DSM Programs; and
- Implementation, monitoring and evaluation of at least two to three demonstration DSM projects.

The programme is aimed at being a practical exercise in the review, identification, design and application of appropriate DSM technologies through the development of replicable demonstration projects.
2 Utility Situation and Background

The Electricity Power Corporation (EPC) is a wholly government-owned utility, established under the Electricity Power Corporation Act of 1972. EPC is in charge for most of the power facilities’ operation in Samoa including planning, generation, transmission, and distribution of electricity.

EPC provides about 95% of the total installed generation capacity of Samoa, supplied through its networks in Savai’i and Upolu. The Upolu system constitutes about 90% of EPC’s total capacity, generated by integrated hydro-diesel networks. EPC’s system in Savai’i is entirely diesel generation. Available data of 1994 shows that EPC charges WS$0.43/kWh ($0.176) for all customers and all levels of consumption and maintains 327 total workforce.

2.1 Overview of Operational Issues

Upolu’s primary transmission network consists of a 32 kV and 22 kV system connected to EPC’s main distribution line in Apia. Secondary distribution is provided via 6.6 kV lines. Primary and secondary distribution system in Savai’i is 22 kV and 6.6 kV lines respectively. Supply voltage to all customers is at 400/230 V, 50 Hz.

Average total system loses of EPC’s is around 16% in 2002 but is expected to increase not until more rigid generation and distribution management programs are implemented. EPC’s load factor for the same year is 60%.

2.2 Utility Characteristics

2.2.1 Generation Capacity

Majority of electricity in Samoa, particularly within the urban grids is generated from diesel and hydropower, while small amount of electricity is produced from biomass (coconut and saw mill residues) and solar energy resources. In 2002, the total contribution of hydropower and diesel generation amounts to 47% and 53% respectively. Power generation from saw mills, predominantly supplied by Samoan Forest Products in Asau is not always sufficiently available most of the time due to saw mill residue shortages, while coconut residue is used mainly for household cooking and operation of small industrial and commercial sectors. Contribution of solar energy to power generation is minimal and limited to water heating and photovoltaic system on small islands and rural lighting and communication.

Samoa consists of 2 main islands, Savai’i and Upolu which covers about 95% of the country’s total land area of 2,935 square kilometers, together with Apolima, Monono and five uninhabited islets. The compacted island group encompasses a total sea area of 120,000 square kilometers. The two largest islands, consumes about 95% of EPC’s generated capacity with total household electrification of 98%.

EPC’s current total installed capacity is 30.805 GW, in hydro-diesel generation ratio of 40:60. In 2002, the hydropower gross generation amounts to 42.565 GWh (47%), whereas diesel is 48.437 GWh (53%), totaling at 91 GWh.
### 2.2.2 Demand Characteristics

Historical and forecast characteristics of both maximum and average demand are shown in the **Graph 2.1** below. Values from 1998 to 2002 are actual values, whereas the succeeding years are forecast values computed from previous years’ values collected from the utility.

**Graph 2.1 Maximum and Average Demand**

![Graph 2.1](image)

Average peak demand of EPC from 1998-2002 is 14.3 MW, while mean average demand value is 14 MW or 98% of the peak demand. Change rate as shown in **Graph 2.3** for both maximum and average demand is almost of the same magnitude, averaging at 5% yearly. Forecast values showed that peak and average demand would change by 4% yearly for the next 10 years.

**Graph 2.2 % Change Rate in Maximum and Average Demand**

![Graph 2.2](image)
2.2.3 Energy Sales Characteristics

Historical and forecast sales volumes of EPC are shown in Graph 2.5 below:

![Graph 2.3 Sales Volume in GWh](image)

Sales volume in 1998 increased from 65 to 83 GWh in 2002 at an average yearly growth rate of 6%. In year 2010, EPC’s sales volume is expected to rise as high as 113 GWh at yearly growth rate of 4% based on available yearly change rate data. Graph 2.7 below illustrates the changes in percent of sales volume from 1998-2002 and forecast values in the upcoming years.

![Graph 2.4 % Change in Sales Volume](image)

Breakdown of sales volume revealed that commercial and residential sectors accounts for about 40% and 37% of EPC’s total sales volume yearly. The remaining amount is shared by industrial and customers other than the sectors mentioned above. The historical and forecast split of the total sales volume between the customer sectors (Industrial, Commercial and
Residential) are shown in Graph 2.9 below and details for 2002 are given in the pie chart, Chart 2.1.

![Graph 2.5 Sales Volume (1998-2010)](image)

In 2002, commercial sector was the biggest consumer with 40% shares of the sales, followed by Residential (29%), Others (24%) and lastly by Industrial sector (7%). The “Others” sector consists of educational institutions, recreational centers and street lighting facilities.

![Chart 2.1 Sectoral Sales Volume in 2002](image)

### 2.2.4 Load Forecast

The Maximum and average demand forecast were outlined in Section 2.2.2. The sales volume forecast, calculated in percent change, of each customer sector is illustrated in Graph 2.11.
The sales volume of “Others” sector showed sudden increase in year 2000 of about 91% but is expected to slow down in the forthcoming years. Except for that year, the Commercial sector has the highest change rate yearly. Forecast change rate from 2003 to 2010 will not alter the customer-sales mix considerably, as shown in Chart 2.3.

2.3 Customer Characteristics

2.3.1 Customer Mix

A summary of customer numbers of each sector in 2002 is illustrated in Chart 2.5. The Residential sector has the highest number of power consumers, taking 92% of the total
customer base. However, the volume of sales shared by the sector is second only to Commercial which accounts for only 5% of the total number of customers. This is so because the individual customer under the Commercial sector consumes larger amount of electricity compared to that of Residential sector. The number of customers of Others and Industrial sectors are proportional to their respective sales volume shares. Customers which are group together as Others sector comprises of school, religion, hotels, government buildings/establishments, etc.

2.3.2 Customer Trends

In the previous years (1998-2002), the number of customers in each sector is very minimal. In fact, both Others and Industrial customers remained constant during that time period. Thus, it is expected that the 2002 customer mix will not differ significantly from the customer mix in 2010.

The electricity consumption per customer per year (MWh/customer/year) for each sector for the period 2000 to 2010 is given in Table 2.1. As expected the Industrial customers show the highest consumption (approximately 3 times higher than the commercial customers). The Residential sector has the smallest energy consumption per customer. Same with the customer mix, the sales to consumption ratio will not change significantly in the forthcoming years since the number of customers across all sectors is constant, unless the consumption of the existing customers will change significantly also.

Although Industrial and Commercial customers are negligible compared to residential, their high consumption takes up almost half of the total sales volume of EPC. Therefore, these two sectors appear to be prime candidates for any DSM activities. On the other hand, due to considerable customer share of Residential sector, adding up their individual consumption still accounts majority of sales and energy requirement supplied by EPC, thus Residential customers can be considered another potential sector for residential-related DSM activities or programs.
Table 2.1 Sales to Customer Ratio

<table>
<thead>
<tr>
<th>Year</th>
<th>Residential</th>
<th>Commercial</th>
<th>Industrial</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>1.6</td>
<td>24.3</td>
<td>92.8</td>
<td>30.9</td>
</tr>
<tr>
<td>2001</td>
<td>1.8</td>
<td>27.3</td>
<td>105.6</td>
<td>31.9</td>
</tr>
<tr>
<td>2002</td>
<td>1.4</td>
<td>38.7</td>
<td>104.5</td>
<td>33.2</td>
</tr>
<tr>
<td>2003</td>
<td>1.4</td>
<td>38.7</td>
<td>104.9</td>
<td>33.2</td>
</tr>
<tr>
<td>2004</td>
<td>1.4</td>
<td>38.7</td>
<td>103.7</td>
<td>33.2</td>
</tr>
<tr>
<td>2005</td>
<td>1.4</td>
<td>38.7</td>
<td>104.5</td>
<td>33.2</td>
</tr>
<tr>
<td>2006</td>
<td>1.4</td>
<td>38.7</td>
<td>103.7</td>
<td>33.2</td>
</tr>
<tr>
<td>2007</td>
<td>1.4</td>
<td>38.7</td>
<td>104.7</td>
<td>33.2</td>
</tr>
<tr>
<td>2008</td>
<td>1.4</td>
<td>38.7</td>
<td>104.3</td>
<td>33.2</td>
</tr>
<tr>
<td>2009</td>
<td>1.4</td>
<td>38.7</td>
<td>104.0</td>
<td>33.2</td>
</tr>
<tr>
<td>2010</td>
<td>1.4</td>
<td>38.7</td>
<td>104.0</td>
<td>33.2</td>
</tr>
</tbody>
</table>

Graph 2.13 shows the percentage change in the annual energy consumption per customer for the period 2000 to 2010. Although the percent change of energy consumption in industrial sector is quite low (below 1%) the real energy consumption per customer averages at 103 MWh/year.

Graph 2.7 % Change of Consumption-Customer Ratio
2.4 System Characteristics

2.4.1 System Load Profile – Weekdays

Graph 2.15 and Graph 2.17 shows the typical weekday load pattern of EPC during rainy season and summer season respectively.

Graph 2.8 Typical Weekday Load Pattern – RAINY SEASON

Graph 2.9 Typical Weekday Load Pattern – SUMMER SEASON

Analysis of the load profiles showed that the system has a base load of around 7-8 MW and system peaks around mid-day (12NN) during summer and early evening (7pm) during rainy season. The major contributors to daytime load are Industrial (primarily base load) and commercial customers (primarily air-conditioning and lighting). The decrease in commercial sector activity in the afternoon (around 5pm) is replaced by the increase in the residential sector activity (primarily lighting, cooling/heating and cooking) resulting in an evening peak
around 7 pm during wet season. During summer, high consumption for cooling across all sectors adds up to the primary loads resulting in a mid-day peak at 12NN. Peak demand during summer (15.6 MW) is higher than the peak demand (14.7 MW) during wet by almost 1 MW.

2.4.2 System Load Profile – Weekends

The system load profiles for the weekends differ from that on weekdays due to reduction in some commercial and industrial sector activity. Typical load profiles during Sundays for both rainy and summer seasons are shown in Graph 2.19 and Graph 2.21 respectively.

Base load during weekends is around 6 to 7 MW for both seasons. Base load and peak values are less than during weekends compared at weekdays due to less commercial and industrial sectors’ operations.

During rainy season, the system shows a nighttime peak of 13.2 MW; at around 8pm. Except for that period, the system load is quite stable at 8-9 MW throughout the day.
During summer, the system shows a nighttime peak of 12.9 MW, at around 7pm. Unlike during wet season where the load increases gradually from 5 to 8pm; for this season the load increases at 8pm and drops afterwards.
3 CURRENT DSM ACTIVITIES

3.1 Programs Proposed under UNDP Program

In 1994, under the UNDP Project “Support to the Pacific Islands Power Sector”, DSM Potential Studies were conducted in 10 utilities of which EPC was a participant. The study was conducted with limited data provided by the utilities and recommended a series of DSM programs that would be applicable to each utility. Proposed programs included the following:

- Compact Fluorescent Lighting Program
- High Efficiency Fluorescent Lighting Program
- Refrigerator Standards and Labelling Program
- Air Conditioner Standards and Labelling Program
- Commercial Refrigeration Equipment Maintenance
- Air Conditioner Equipment Maintenance Program
- Interruptible Rates for Large Customers
- Energy Audits for Large Customers

3.2 Programs Implemented

A feasibility study for the introduction of Appliance Labeling and Standards in the Pacific Islands was conducted in 1996. The study concluded that there were significant benefits to the Islands by the introduction of such measures. One of the reforms implemented in the past years, which is in harmony with the national energy policy formulated by the Samoan Government addresses the issue on energy efficiency and conservation. The approach developed for energy efficiency provides for the introduction of a Standards and Labeling program for domestic appliances and is currently being initiated with the commencement of the public awareness programs to increase people’s knowledge and awareness on the importance of energy.

The EPC has also taken a proactive role in the energy sector of Samoa through its supply and demand side management program undertaking technical assistance to utility customers on energy efficiency measures to enable daytime load reduction.

3.3 Planned DSM Activities

EPC focuses on reducing the system peak demand that occurs between 9am and 5pm on weekdays in order to reduce the extent of thermal generation. EPC’s customer tariff structure has been developed assuming the use of both hydro and thermal capacity to meet the majority of the base load and peak-hours use of portion of the thermal generation to manage peak demand. Complementing its demand side management effort to enhance the efficiency of the power network is a program on system losses reduction wherein the utility invests on services for thermo-scanning the distribution system and replacing old meters with the state-of-the-art electronic type meters.
4 DSM OBJECTIVES

4.1.1 Corporate Objectives

EPC’s corporate objectives are to provide reliable and responsive electricity service to all its customers at a reasonable cost, increase electrification to uplift quality of life in rural areas, and reduce electricity demand and use of fossil fuels for the generation of electricity.

4.1.2 Load Shape Objectives

The load profile recorded in January 2003 shows a maximum demand of 15.6 MW and a base load of around 7.8 MW during weekdays. For weekends, maximum demand and base load are 13.2 MW and 7.7 MW respectively. The summary of maximum demand and period is shown in Table 4.1 below:

<table>
<thead>
<tr>
<th>Day (Jan 2003)</th>
<th>Max Demand</th>
<th>Base Load (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mon-Fri (Excluding public holidays)</td>
<td>15.6</td>
<td>9.00-11.00 a.m. and 7.00-9.00 p.m.</td>
</tr>
<tr>
<td>Sat-Sun (Including public holidays)</td>
<td>13.2</td>
<td>7.30-8.30 p.m.</td>
</tr>
</tbody>
</table>

The major contributors to the base load of EPC are the engineering industry of Samoa including food processing, metal fabrication, plastics, boat building, paper products, automotive products and engineering services that normally operate continuously throughout the week. The weekday morning and early afternoon peak is normally caused by the Commercial sector and the major end-use could be attributed to air conditioning. The system also shows an evening peak of around 15MW and this could be attributed to the residential sector from lighting and other domestic appliances (TV, electric cookers, fans etc).

As seen from the table above, the ratio of base load to max demand of EPC is about 50%. From the analysis of the historical and forecast sales volume the load factor is expected to be around 59%, as shown in Table 4.2. The load factor is calculated from the ratio of actual annual sales volume (GWh) to annual sales volume at maximum demand. Improvement in the system load factor is regarded as a primary load shape objective to any utility.
Table 4.2 Historical and Forecast System Load Factor

<table>
<thead>
<tr>
<th>Year</th>
<th>Sales Volume (GWh)</th>
<th>Max Demand (MW)</th>
<th>Load Factor (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>65.36</td>
<td>12.7</td>
<td>58.75</td>
</tr>
<tr>
<td>1999</td>
<td>67.68</td>
<td>13.3</td>
<td>58.09</td>
</tr>
<tr>
<td>2000</td>
<td>71.35</td>
<td>14.4</td>
<td>56.56</td>
</tr>
<tr>
<td>2001</td>
<td>78.68</td>
<td>15.2</td>
<td>59.09</td>
</tr>
<tr>
<td>2002</td>
<td>82.90</td>
<td>15.8</td>
<td>59.89</td>
</tr>
<tr>
<td>2003</td>
<td>86.21</td>
<td>16.4</td>
<td>59.89</td>
</tr>
<tr>
<td>2004</td>
<td>89.66</td>
<td>17.1</td>
<td>59.89</td>
</tr>
<tr>
<td>2005</td>
<td>93.25</td>
<td>17.8</td>
<td>59.89</td>
</tr>
<tr>
<td>2006</td>
<td>96.98</td>
<td>18.5</td>
<td>59.89</td>
</tr>
<tr>
<td>2007</td>
<td>100.86</td>
<td>19.2</td>
<td>59.89</td>
</tr>
<tr>
<td>2008</td>
<td>104.89</td>
<td>20.0</td>
<td>59.89</td>
</tr>
<tr>
<td>2009</td>
<td>109.09</td>
<td>20.8</td>
<td>59.89</td>
</tr>
<tr>
<td>2010</td>
<td>113.45</td>
<td>21.6</td>
<td>59.89</td>
</tr>
</tbody>
</table>

* Load Factor = (Annual Sales Volume (GWh) x 1000) / (Max Demand x 24 x 365) x 100

There are several load shape objectives available to the DSM planner. These include:

- **peak clipping** — the reduction of utility load primarily during periods of peak demand
- **valley-filling** — the improvement of system load factor by building load in off-peak periods
- **load shifting** — the reduction of utility loads during periods of peak demand, while at the same time building load in off-peak periods. Load shifting typically does not substantially alter total electricity sales.
- **conservation** — the reduction of utility loads, more or less equally, during all or most hours of the day
- **load building** — the increase of utility loads, more or less equally, during all or most hours of the day
- provision of a more **flexible utility load shape** — refers to programs that set up utility options to alter customer energy consumption on an as-needed basis, as in interruptible/curtailable agreements.
The current emphasis for EPC is the reduction in thermal generation and this could be achieved by restricting the system demand at or around the hydro capacity (approximately 12.4 MW in 2003). Hence, peak clipping and load shifting could be considered as primary load shape objectives applicable for EPC.

### 4.1.3 Non-Load Shape Objectives

The non-load shape objectives include improving customer relations, expanding electrification in rural areas, improving quality and reliability of service, distribution system (technical and non-technical) losses, and considering environmental impacts from the use of fossil fuel for electricity generation.

#### Table 4.3 Transmission and Distribution Losses

<table>
<thead>
<tr>
<th>Year</th>
<th>Technical &amp; Non-Technical (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>15</td>
</tr>
<tr>
<td>1999</td>
<td>16</td>
</tr>
<tr>
<td>2000</td>
<td>16</td>
</tr>
<tr>
<td>2001</td>
<td>17</td>
</tr>
<tr>
<td>2002</td>
<td>18</td>
</tr>
</tbody>
</table>

One of the major operational issues that EPC aims at improving is its system loss of 15% to 18% as shown in Table 4.3. In order to keep this network losses into a single-digit level, a two-pronged approach of system loss reduction program is required, and is initiated with the conduct of a loss-related evaluation of utility distribution facilities and review of consumer accounts. There are two types of losses in a power system: power losses associated with the electrical characteristics of the power system, called technical losses, and power losses associated with errors derived from the revenue metering, billing and/or collection, called
non-technical losses. EPC is currently undertaking a program on Prepaid Metering to this effect.

In the usual configuration for prepaid metering, purchases of electricity are recorded on a smartcard. This card is then inserted in a display unit within the site. Through the display unit, consumption is recorded and value is removed from the card. Service is discontinued once this card is out of purchased service, and until the smartcard is reloaded by purchasing more from utility or its outlet.

4.2 DSM Program Options

4.2.1 Base Load Reduction from Industrial Sector

Because the major contributors to base load are a few strategic industries, i.e. food processing, metal fabrication, plastics, boat building, paper products, automotive products and engineering services, and the industrial sector is the highest energy consumption per customer (MWh/year), base load reduction from industrial sector is set as first priority to be examined.

A full-scale detailed energy audit is required to identify potential energy saving measures in interesting participants. The energy saving measures may come in the form of:

- Higher efficiency system and appliances - high efficiency chillers, high efficiency air conditioners, high efficiency compressors, regenerative burners, better insulation, high efficiency heat exchangers, high efficiency motors, high efficiency reflectors, high efficiency lamps and ballasts;
- Alternative sources of energy - solar hot water heaters, direct- and indirect-fired absorption chillers;
- Improved system maintenance;
- Improved operation and control procedures; and
- Other energy saving technologies - evaporative pre-cooling, heat pipes, infrared heaters, variable speed drives, recuperators, economizers, automatic drainage systems, power factor correction, etc.

Some energy saving measures may not directly reduce the energy consumption but they aim to reduce peak demand. For example, ice storage systems for refrigeration and/or air conditioning aims to eschew electricity consumption during peak period. During off-peak periods, the system consumes electricity to store cooling medium such as water or ice and the stored cooling medium would be used during peak period.

4.2.2 Energy Efficiency and Management Program in Commercial Sector

The Commercial sector is the biggest electricity consumer of EPC accounting for around 39.8% of the total sales in 2002. It also contributes to the maximum demand during the weekdays. From the historical data, commercial sector represents the steadiest growth of energy consumption per customer with forecast expansion at approximately 4% annually.
There are two major electricity end-uses in commercial sector, namely, air-conditioning and lighting systems. Air-conditioning systems generally account for about 50-60%, while lighting systems accounts for 10-15%, of end-use consumption.

When raised as source of option for demand-side management, the potential electricity end-uses described above exhibit several significant technical attributes that can be exploited to conserve energy. Full-scale detailed energy audits are required to identify cost-effective opportunities for efficient technologies specific to each customer. Some of the options are:

4.2.2.1 Efficient Air-Conditioning Systems

There are many types of air-conditioning systems depending on the type of building and air-conditioning needs. In addition, there are also many ways of improving the operation of existing air-conditioning systems. Reduction in energy consumption and demand can be achieved together with comfort improvements for building occupants.

Air-conditioning equipment fall into two broad categories:

- Package units (smaller units in residential sector and somewhat larger units in commercial sector), and
- Central air-conditioning plant for large commercial buildings.

Some air-conditioning equipment is more efficient than others and customers can be provided with information about the efficiency of equipment during procurement. There are appliance standards and labeling programs implemented in many countries and these form a good basis of comparison of different models and provide valuable information during purchase.

Simple maintenance of air-conditioning systems offers opportunities to save energy and improve occupant comfort at the same time. Such maintenance procedures include:

- Regular cleaning of air filters, condensing units
- Checking ducting for leaks or cracks and repair

In addition, proper design, operation, and control of air-conditioning systems will result in energy saving and longer operation life. Some suggestions include:

- Use of timer controls for air conditioning system operation
- Maintain thermostat settings or room temperatures at no lower than 25° C
- Always close window and doors of air-conditioned area
- Use blinds, curtains or external shading to minimize solar heat gain
- Design new buildings on an orientation that will minimize solar heat gain
- Balancing of air flows throughout the building in accordance with the existing conditions.
4.2.2.2 Efficient Lighting

Several lighting technologies are available that offer lower electricity bills for customers and having significant system benefits to the utility while maintaining same or improved comfort levels.

Compact Fluorescent Lamps (CFLs)

Compact Fluorescent Lamps (CFLs) are quite different from the long tube style fluorescent lamps and they can be used with standard incandescent light globe fittings. This makes them ideal as a replacement for traditional incandescent light globes.

CFLs are much more expensive than incandescent globes, but they use only about one-fifth of the energy – a 20 watt CFL down light is equivalent in light output to a standard 100 watt incandescent globe. CFLs also last for far longer – about 8,000 hours for 8 years in a typical house rather than 1,000 hours or 1 year for an incandescent. CFLs have two parts – a ballast and globe. Two-part CFLs allow a new lamp to be fitted with the original ballast.

There are several CFL Programs that have been implemented in utilities around the world as a part of DSM activities. The initial barrier of high capital cost of a CFL has been addressed in several ways – offer of rebates, inclusion of costs in the electricity bill etc.

Linear Fluorescent Lighting

The use of high efficiency linear fluorescent lamp, 36 and 18W, instead of standard 40 and 20W, shows a simple energy saving measure. The price of high efficiency and standard type is roughly the same and the manufacturer claims that the service life of an energy efficient 36W tube is 20,000 hours, compared with 7,500 hours for the 40W. The high efficiency lamps are suitable for the existing fittings of the standard lamps.

Generally, there are two alternative lamp replacement schemes:

- Wait until the existing lamps reach the end of their service and replace them with energy efficient lamps, or
- Discard the existing lamps and replace them with energy efficient lamps.

High Efficiency Lamps

High Intensity Discharge (HID) lamps offer significantly higher efficacy and better color rendering index than incandescent lamps. They are well suited to replace incandescent and tungsten halogen lamps. In terms of operating life, they are around 10,000 hours – approximately 10 times longer than ordinary incandescent lamps. The two most common types of HID lamps are metal halide and high-pressure sodium lamps.

Metal halide lamps offer as high efficacy as up to 125 lumen/watt of white light. The color rendering index of the lamps allow their use in virtually all applications where high light output and accurate color are required. The wide range of color spectrum of metal halide lamps coupled with the excellent optical control potential of the sources, makes them ideal for replacement of less efficient tungsten halogen or incandescent lamps used for floodlighting, area lighting, and high quality industrial lighting.

High-pressure sodium (HPS) lamps offer efficacy up to 140 lumen/watt, which are higher than most metal halide lamps. However, their major disadvantage includes low color
rendering index that leads to limited applications. Typical applications of HPS are the use of outdoor lighting, i.e. parking lots, storage, sports, and recreational, where color accuracy is not high.

**Energy Efficient Ballasts**

Energy efficient ballasts are designed to reduce internal losses by improving mechanical and electrical characteristics. Generally speaking, there are two common types of energy efficient ballasts, ferromagnetic and electronic ballasts. In ferromagnetic ballasts, more efficient magnetic circuits, closer spacing of coils, and improved insulation systems can result in loss reductions of approximately 50%, compared to conventional units. The losses range from 4-10 watts, depending on ballast make. In electronic ballasts, magnetic circuit is replaced by the operation of high frequency, about 20 kHz, and electronic circuit. The loss of electronic ballast is less than 4 watts.

**High Efficiency Light Reflectors**

High efficiency light reflectors can be a very cost effective way of reducing lighting bills in commercial and industrial sectors. Savings of up to 50% can be achieved depending on the installation. High efficiency reflectors are widely available for fluorescent fittings. With proper lighting design, the installing of reflectors allows the use of fewer fluorescent lamps per fixture while maintaining the required levels of lighting.

Reflectors work by directing more of the light downward from the fitting. Using reflectors can also control glare, by directing light where it is required. A wide variety of high efficiency reflectors are available, including parabolic, silver mirror, and powder coated reflectors.

High efficiency reflectors can be easily fitted into existing fluorescent fittings, making them one of the simplest and cheapest lighting efficiency improvements to undertake. Retrofitting reflectors is most economic in areas where the actual lighting level is greater than required.

**Switches, Controls and Using Daylight**

The simplest form of lighting control is to switch off lights when not needed or when there is adequate daylight. People can easily turn off lights when they leave an area, but this can be inconvenient if the switch controls a number of lights over a large area. Having more switches in order to provide more individual control in smaller areas can be a simple and low cost solution. Other controls, which can be used to reduce lighting bills, include:

- Annual time clocks and switching systems, which control the time lighting is turned off in buildings
- Automatic light dimmers, which dim the lights as the amount of daylight increases, and
- Automatic sensors, which turn off or dim lights when an area is unoccupied, and turn on when an area is occupied.

**Efficient Refrigeration**

Many manufacturers in refrigerator design are achieving improving energy efficiency in refrigeration. Developments to increase the efficiency of refrigerators include improved compressor efficiency, higher insulation levels, redesign of the refrigeration cycle, reduced capacity of resistance defrosting heaters, and improved controls.
As with air-conditioning equipment, some refrigerators and freezers are more efficient than others. Customers can be provided with information about the efficiency of the refrigerators or freezers equipment they are considering buying – for example, through a Standards and Labeling program.

Proper refrigeration maintenance and operation are ways of effective means for ensuring running efficiency. Refrigeration equipment such as cold rooms, freezers and refrigerated display cases widely used in hotels, restaurants and food chains need to be continually maintained. Such maintenance procedures include:

- Door closes tightly and gaskets are in good shape
- Temperature is set correctly
- Ice does not build up
- Condensers cooling fins and motors are clean
- Locating the refrigerator and freezer away from direct sunlight
- Allowing adequate air flow around the motor and condenser fins

4.2.3 Efficient Lighting and Appliances in Residential Sector

The EPC system load shapes indicate an evening peak demand of around 13 to 16 MW primarily caused by increased residential sector load between 7 to 9 pm.

At a growth rate of 4 percent for both electricity demand and customers number, average energy use of household which is estimated to be 1.4 MWh per annum would further increase in actual value as households beginning to acquire high load devices of which the less efficient varieties that are cheaper and so more common may consume up to 10% - 30% more. This is likely to effect maximum peak consumption as households turned on simultaneously to operate appliances during peak hours.

There are many ways to make the households more energy efficient and consequently modify EPC’s load profile to meet its demand-side management objectives. These options can be used not only to reduce or shift peak load, but also can realize increase demand during off-peak periods, provide strategic conservation or load growth, or allow for flexible load management.

Lighting accounts for about 15 percent of the typical residential customer’s electrical consumption. It is a small load per household, but collectively it can be large. Studies in other countries have shown that residential lighting to have a significant impact on the peak demand and efficient lighting programs – CFLs and high efficiency fluorescent lighting have the potential for peak clipping.

From EPC perspective, the energy used by electric ranges is an important consideration because the saturation of electric ranges is increasing and they are generally heavily used during peak load periods. The survey of household standards and living conditions shows that 11 percent of Samoans use electricity for their cooking requirements. Energy-efficient cooking equipment may provide reduction in energy usage by as much as 14 percent for
households that use conventional electric range. An example of these energy saving devices is a microwave oven or combination microwave/convention oven.

In addition, the use of high efficiency refrigerators and air-conditioners has the potential for peak reduction and subsequent lower energy consumption. As is the case with the preceding opportunities, benefits of reduced electricity consumption cannot be captured by simple substitution of one technology with another. Customer awareness program aimed to effect changes in customer behavior or improvements in maintenance practices is required to educate consumers on energy saving measures that could be undertaken by them to reduce electricity costs. For example, distribution of “user friendly” brochure with information on the running costs of the appliances along with suggestions on how to attain energy saving through keeping their refrigerator coils clean, or preventing inefficient operation due to air conditioner filters lack of maintenance.
APPENDIX 1 : UTILITY DATA
# UTILITY INFORMATION

## 1. System Characteristics

1.1 Supply Frequency  
50 Hz

1.2 Supply Voltages  
1.2.1 Primary Distribution  
6.6, 22 & 33 kV

1.2.2 Secondary Distribution  
400 & 230 V

1.3 Supply Coverage (Year 2003)  
1.3.1 Area Electrified (approx.)  
98 %

## 2. Installed Capacity (Year 2003)

2.1 Hydro  
12,385 MW

2.2 Thermal  
2.2.1 Heavy Oil  
MW

2.2.2 Diesel  
18,420 MW

2.2.3 Gas  
MW

2.2.4 Others (please specify)  
2.2.4.1  
MW  
2.2.4.2  
MW


3.1 Hydro  
42,565 GWh

3.2 Thermal  
3.2.1 Heavy Oil  
GWh

3.2.2 Diesel  
48,437 GWh

3.2.3 Gas  
GWh

3.2.4 Others (please specify)  
3.2.4.1  
GWh  
3.2.4.2  
GWh

## 4. Fossil Fuel Consumption in Electricity Generation (Year 2002)

4.1 Heavy Oil  
litres

4.2 Diesel  
12,666,174 litres

4.3 Gas  
cu.m

4.4 Others (please specify)  
4.4.1  

## 5. Average System Load Factor

60 %

## 6. Average Transmission and Distribution Losses

16 %

## 7. Power Market (Year 2002)

7.1 Peak Demand  
7.1.1 Peak Demand  
15 MW  
December

7.2 Number of Customers  
7.2.1 Residential  
17,467 units

7.2.2 Commercial  
1,726 units

7.2.3 Industrial  
36 units

7.2.4 Others (please specify)  
7.2.4.1  
School, Religion, Hotels, Government

7.3 Annual Electricity Sales  
7.3.1 Residential  
24,204 GWh

7.3.2 Commercial  
32,975 GWh

7.3.3 Industrial  
5,651 GWh

7.3.4 Others (please specify)  
7.3.4.1  
School, Religion, Hotels, Government

20,862 GWh