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System Losses in the Power Sector and the Impact of Pre-Paid Electric Meters as relates to Loss Reduction. A Guyanese perspective

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INTRODUCTION

Power utilities worldwide have the mandate of providing a safe, affordable, adequate and reliable supply of electricity. This goal continues to be evasive in most of the Caribbean regions, as a direct result of the system losses that continuously plague them.

System loss can be defined as "the difference between the total output generation and that generation sold to the customers". These losses comprises of two essential components: Technical and Non – Technical losses.

Technical losses are related to the physical nature of the equipment and the infrastructure of the power system i.e. copper loss, transformer, switches, generators etc. In contrast Non- Technical losses are caused by actions external to the power system. Possible reasons are:

I. Electricity theft
II. Faulty meters
III. Consumers not on the data base
IV. Consumers in the wrong tariff category

The Guyana Power and Light Inc, the only power utility in Guyana is Government owned. Their system losses have rapidly increased from 20% in 1993 to an unprecedented 40% at the end of 2005, the cost to the Cooperation is the estimated 6 **billion Guyana dollars** or **30 million United States dollars** per annum**.** These losses are estimated at16% technical and 24% to Non - Technical. Translating to a non-technical revenue loss of **5 billion dollars** or **25 million US**.

Guyana Power and Light incorporates a 24% ceiling of acceptable loss into its accounts and as such it is in its best interest to reduce system losses urgently, with Non- technical losses taking precedence over all others.

Electricity is a prerequisite to economic growth and quality of life. However, in order to pay for the cost of generation and to operate profitably, utilities need to collect payments from their consumers in a timely and reliable fashion. Pass-due accounts disconnect/reconnects and bad debt drives up the cost of electric service, depleting operating margins and making it difficult for utilities to expand their services.

Desperate attempts have been made; the utility however has still proven nonproficient in this aspect. Losses remain unacceptably high.

If this performance prevails the utility will continue to operate at highly inefficient levels, and incapable of attaining acceptable performance standards as outlined in its license.

This presentation aims at outlining the non-technical aspect of system losses while concurrently examining the implementation of a prepaid meter system as arguably the most plausible solution to this seemingly irresolvable problem.

NON-TECHNICAL LOSSES

Non-Technical losses which is in most part a direct result of electrical theft (The use of meter bypass or direct connection to the low voltage line) and poor billing practices are the major constraints faced by the utility in its ongoing battle against the system loss opponents. The utility due to these constraints has been unable to honor its obligation to its customers.

In the design of a tariff rate the utility has an obligation to provide its service at a cost that is attractive and competitive, a goal that GPL is yet to achieve. Because of these ensuing losses the utility is forced to pass down its financial inadequacies down to the already burdened consumer either in the form of an unacceptable power supply or increased tariffs. Both these reasons have inevitably contributed to decisions made by a

few major industrial consumers to use self generation as an alternative to the service of GPL.

Billing

The billing system employed by GPL is quite cumbersome and not fully computerized, most calculations and verifications are manually done. The result is an enormous amount of human input into an already inaccurate system, which in retrospect contributes to inaccurate billing and disenfranchisement of consumers. The Power Planning Association Ltd (the Consulting Service for Evaluation and Prioritization of Loss Reduction Investments, specifically assigned to the Unserved Areas Electrification Program in Guyana) in their report outlines a typical example of inaccurate billing as demonstrated below

Period	**Date**	**reading**	**Consumption**	**Type**
30	10/08/05	1750	125	A
29	09/08/05	1625	151	C
28	08/08/05	1834	151	E
27	07/08/05	1683	151	E
26	06/09/05	1906	151	A
25	05/09/05	1755	148	A

Key: A = Actual; C = Correction; E = Estimate

The report also highlighted the systems lack of basic components that would ensure its efficiency, some existing deficiencies are

- The system no self check capability,
- Has no capacity for retrospective adjustments,
- Cannot easily accommodate mid-month meter changes.

- Has no record of meter or service status.

- Has relatively limited and inefficient search facilities.

- Holds very limited customer information and provide only limited management information.

- Requires a substantially high level of system maintenance.

Another factor needing consequential consideration as it relates to the billing system is the large geographic area GPL covers and the inadequacy of available personnel to accomplish this exceedingly significant yet difficult task.

Because of these inherent limitations the utility's commercial department is forced to issue estimated bills, which in some cases have proved inaccurate. For example if an individual vacates a premises for a period of say 3 weeks and the utility estimates the bill for that billing period, the utility has no means of determining whether the individual was legitimately absent or if fraudulent activities were conducted. This inherently will plant the seed of doubt in the minds of already disgruntled consumers as to the legitimacy of the bills issued.

Theft

Electricity theft is an international problem resulting in the loss of billions of dollars annually. Over the years ingenious methods of electricity theft in Guyana have been observed. Some of these include:

- Tampering with meter seals: This gives the perpetrator full access to the meter therein allowing the individuals to alter the meter's operation in whatever way they choose.

- Direct connection to the grid: The meter is completely bypassed and the individual receives a zero reading on their bill. Some perpetrators however remove the bypass intermittently so as to incur a minimal charge and to camouflage their fraudulent activities.

- Slowing down the spinning disc in the meter. This could be accomplished in a number of ways for e.g. placing sand on the disc or employing the use a magnet.

Illegal connections tend to overload a system, which causes tripping and result in power interruptions. The overload could also result in over voltages and damage to appliances of paying customers. There is also a safety factor involved, since illegal connections can lead to fires and loss of human life.

Persons are however willing to risk both life and limb to maintain the illegal supply of electricity at their premises.

GPL is currently expanding their network into un-served areas under a program funded by the International Development Bank (IDB). The agreement existing between the Government of Guyana and IDB necessitates a capital contribution of a mere GY$15,000 or 75 US$ per household in these newly electrified areas. To date a mere 25% of those residing in these areas have paid for the program.

Why pay when it is possible to steal?

The PPA in their report suggested that the rational of Guyanese is “it is generally not the inability or in many cases the unwillingness to pay. Rather the opportunity not to pay that is taken when presented.”

To eliminate Non – technical losses the utility has allocated a multiplicity of resources, nevertheless their efforts have produced disappointing results. The culture of the people remains unspoiled.

Systems implemented by the utility in there fight includes:

- The intermitted raids in areas known for stealing.
- Back billing of customers found with tampered meters.
- Disconnection of service of repeating offenders.

None of the above proved significantly effective.

This continued culture of electricity theft is a plague that has to be eradicated if the industry is to remain sustainable and viable.

As Utilities despairingly search for ways to deal with non- technical losses, **has the development of prepaid meters become the welcomed alternative?**

PREPAID METERING

Prepaid metering in its simplest form refers to the paying of electricity, gas or water before it is used. Consumers simply purchase credit which they use until it expires. This concept had its birth in the UK well before World War II where a coin system was employed; hence it is not a recent discovery. Quantum leaps, however, took place in the 1980s when electronic transfer of the credit was introduced.

Over 40 countries have partially adopted the prepaid meter system. As previously highlighted, the United Kingdom has had them in use for the better part of 80 years and currently boasting over 3.5 million prepaid metered consumers. The program started in South Africa sometime in 1992, which to date has installations of over 6 million. Other African nations following this trend are Sudan and Madagascar. The motif has found ground in New Zealand and our South American neighbour Argentina have all installed a

few thousand prepaid meters. The Government of Ontario has established targets for the installation of 800,000 prepaid meters by December 31, 2007 and installation of prepaid meters for all Ontario customers by December 31, 2010.

Prepaid meters have evolved from the conceptual stage of coin and token use to today's keypad, Smartcard and two way network AMR. The most utilized prepaid meter today, however, is the smart card operated meter. This being as a result of its feasibility coupled with the fact that it is virtually tamper proof; it therefore becomes the most logical choice for Guyana's environment.

Smart Card System

The smart card operated system allows consumers to purchase a reusable energy debit card for the amount of KWH they require. The cards are individualized thus keyed to the individual's meter and account number. If anyone attempts to utilize a card belonging to another customer the meter would not accept it. An operating feature based on it being programmed with the random based algorithm also used by credit cards and GSM phones (takes over a million hours to brake). The card is simply passed in front of the meters integrated card reader; the meter then resets to the amount of credit contained on the card.

The meter is completely sealed and has no moving parts so its reliability is improved. Today smart card operated meters are stand alone, requiring no separate in house keypad or onsite programming. The card is designed to capture all transactions and consumption information, thus every time the customer purchases credit the utility receives valuable information as to the customer's usage patterns. This can be of critical importance with respect to tampering and accurate load forecasting. Specific tampering information is written to the card. The Utility's internal software can also be designed to detect non-purchase of credit for prolonged periods.

For the purpose of retaining some form of human consideration today's prepaid meters are equipped with an emergency energy facility allowing consumers whose purchased

units are depleted a fixed credit limit deductible upon their next credited card insertion. APPENDIX 1 shows technical characteristics of a typical prepaid meter.
Tennessee Valley Infrastructure Group (TVIG) in their financial analysis for a project titled Self Managed Meters / Prepaid Meters Acquisition (Consumers in arrears or slow paying) arrived at the conclusion that if a total of 7,500 prepaid meters were installed at an average energy consumption of 367KWH per month it would be possible recover the capital expenditure or break even within a matter of 1.63 years. APPENDIX 2. This is a comprehensive analysis that can be used as a financial model for any future endeavors by GPL to adopt the prepaid system.

GPL should conduct a study implementing the prepaid meter system based on the numerous advantages it presents

1) **Improved operational efficiencies:**
    - ❖ There exist eliminated costs as relates to meter reading since none are required.
    - ❖ The administrative charges associated with disconnection and reconnections ceases to exist.
    - ❖ Controls usurpation of electricity more effectively than conventional meters.

2) **Reduced Financial Risk:**
    - ❖ Payments are in advance so cash flow is improved.
    - ❖ Eliminates need for billing system thus removing the discrepancies associated with it.
    - ❖ Eliminates bad debt by an average of 5%

3) **Better Customer Service:**

- ❖ The system eliminates billing delays

- ❖ Promotes the consumption of electricity thus allowing consumers to save money through better energy management.

REGULATORY ISSUES

Electricity to some is perceived as a right rather than a privilege thus over the years some regulatory bodies primarily in the United States have instituted laws providing a protective umbrella for defaulters of electric bill payments, stating that, "every avenue for collection must be exhausted before disconnection occurs". This does not allow for prepaid meters implementation with its abrupt cutoff policy.

In Guyana, however, the law should allow the utility to upgrade their system in whatever feasible way deemed necessary so as to reduce system losses be it technical or non technical.

The legislation should ensure that the utility fulfills its obligation to its customers as it relates to the inevitable increase in profits being enjoyed by the customer in the form of reduced tariffs, as mandated in its license.

Some additions may have to be made to the existing electricity sector reform act 1999 to make provision for whatever technical specifications may be mandatory for effective implementation and regulation of the prepaid system. These adjustments would not weaken the legislation from ensuring the safe accurate and efficient provision of electricity by the utility.

CONCLUSION

Guyana as in many Caribbean regions has a prevalent culture of electricity pilfering; thus prepaid metering should not be viewed as an injustice to society. It preferably should be viewed as a means of putting control into the hands of the consumer; giving them an opportunity to make informed decisions as relates to consumption practices while simultaneously because of the resultant physiological effect, encourage them to pay as they go for the privilege of electrification.

The utility will benefit from this technological step forward, such that, it will be given the financial tools necessary for the provision of acceptable service to its consumers. Utilities will be positioned for a proactive response to service issues, instead of relying on customers to inform them when problems arise, thereby reducing the number of customer calls and the cost of delivering customer care.

Furthermore the need for an effective loss reduction program is the ultimate desideratum of the Guyana Power and Light Inc. Thus even though to some may perceive the initial cost of the prepaid system to be daunting the resulting benefits are phenomenal.

It is unarguable! The prepaid meter system must be the cornerstone of any effective loss reduction program.

The ultimate question therefore should not be how much it will cost the utility to implement such a system; rather, how much will it cost them to not implement it.

REFERENCE

1) Guyana Unserved Electrification program Consulting Services for Evaluation and Prioritisations of Loss reduction Investments.
2) http://www.frost.com/prod/servlet/market-insight-top.pag?docid=27962688
3) Sloan "Current Affairs - Prepayment a Viable Solution to Energy Thee' Metering International, issue 4, 1998.
4) http://www.tvigroup.com/Meters_Producs.html

APPENDIX 1

TECHNICAL CHARACTERISTIC

- Solid-state meters are reliable and accurate measuring devices for energy consumers
- Suggested usage: Commercial and Industrial applications
- Class: IEC 1036 Class 2.0, 1.0;
- 4 tariff zones
- Support Smart Card IEC 7816
- Digital communication interfaces
- Open architecture IEC1107 optical port
- 8-digit LCD
- PM Communicator software

Excel. 1. Technical characteristics

Class	1.0;
Nominal voltage	115V, 120V, 220V, 230V
Basic (maximum) current:	5(20)A 10(50)A 20 (80) A or 25(100)A
Tariff zones 4 seasons	24 dayzones, weekends and holidays, daylight savings time
Operational temperature	- 40C to + 60C;
Power loss	less than 2 W;
Frequency	45…65 Hz;
Humidity	95%
Serial circuits resistance	0,0005 Ohm;
Clock accuracy	<0.5sec daily
Internal constant	1000 imp/kWh
Communication protocol	IEC 1107;
Self-test	optical port communication inquiry, power outage and once a day at 2 am
Data transfer speed:	optical port, RS-485, PLC... 300…9600bod;
Power outage, time correction log	up to 500 occurrences
Security:	password, hardware lock;
Standard warranty	3 year;
Extended warranty	8 year;
Recalibration period	>15 years;
Lifetime	30 year;
Protection	case and terminal cover IP 54, terminals IP 20;
Fire test:	Complying with IEC 695-2-1.

USAGE

Solid-state meters are used for measurement and control of electric power, such as:

- Measuring in multi-tariff mode of active and reactive energy and demand
- Import and export of power
- Load control and management

REFERENCE STANDARDS

Solid-state meters confirm and, for some parameters, - exceed requirements:

- Communication protocol IEC1107
- Pulse output DIN3864.
- Time-of-use switching - IEC1037

MECHANICAL

Meters are equipped with current and potential sensors, PCB with solid-state measuring circuit. Measured values and other parameters are displayed on 8-digit LCD.
CPU enables the meters to be programmed and to perform various functions. CASE is made of strengthened polycarbonate and is rectangular, bottom-connected. The position of installation screws and sizes confirms to DIN43859 standard. The meters can be installed in almost any electric room or DB. Access to measuring circuits, faceplate and terminals is restricted by sealing. Waterproof multifunctional button doesn't decrease the protection class of the case. Thus, meters could be used in any climatic zone.

PCB COMPONENTS

Main components are located on PCB by SMD or through-hole mounting.

- Three-phase power source
- Potential splitters
- CPU
- Quartz oscillator
- 32 kHz RTC quartz oscillator
- Measuring IC
- Multifunctional button

- 8-digit LCD

POWER SOURCE

Class 1 meter using the same PS, except for fixed voltage.

ANALOG-DIGITAL CONVERSION AND CALCULATION

ADC is appropriately measuring the input signal of potential and current on each phase, which is then multiplied. Calibration constants are factory pre-programmed and stored and EEPROM. This allows for self-test and immediate self-correction of the meters.

EEPROM

The following data is stored in EEPROM:

- Configuration
- Constants
- Active and reactive (import and export) energy by tariff and billing zones
- Demand log
- Previous tariff data
- Number and dates of power outages
- Current and maximum demand by tariff zones

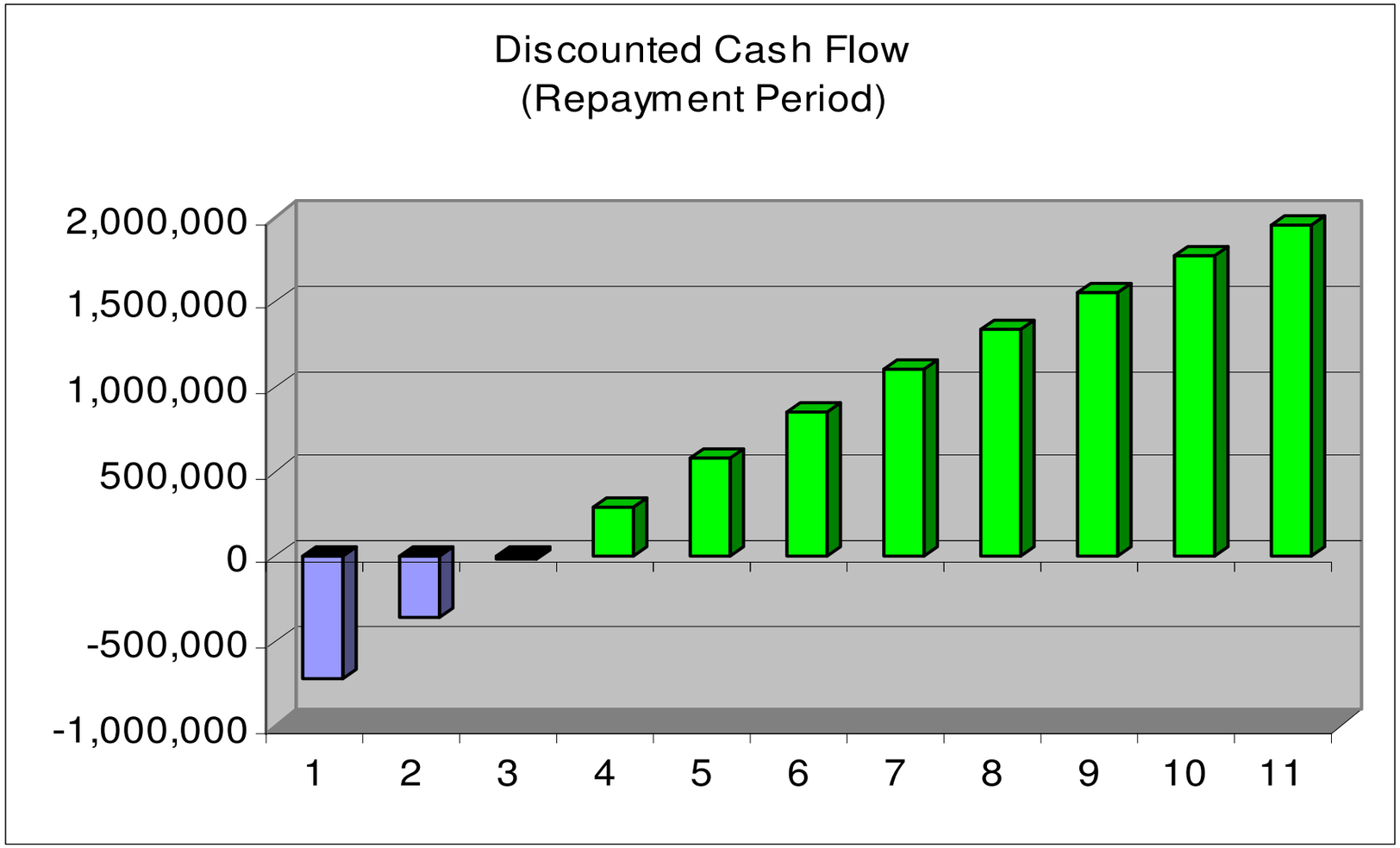
BATTERY

Lithium battery allows for a minimum of: 10 - year power-off storage of load profile, clock data and calendar. 5 - year power-off 5 - minute per month energizing for the purpose of reading the meter.

SMARTCARD METER

Periods	0	1	2	3	4	5	6	7	8	9	10
SAVINGS / INCOME BY BENIFITS	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Savings in operation costs: Reading & Distribution		22,500	23,063	23,639	24,230	24,836	25,457	26,093	26,745	27,414	28,099
Savings in operation costs: Disconnection & Reconnection		14,400	14,760	14,760	14,760	14,760	14,760	14,760	14,760	14,760	14,760
Savings in operation costs: Electrical meter maintenance		7,500	7,688	7,688	7,688	7,688	7,688	7,688	7,688	7,688	7,688
Savings in administrative Overhead		2,500	2,563	2,563	2,563	2,563	2,563	2,563	2,563	2,563	2,563
Benefits of pre-payment: Finance savings on normal payments		29,424	30,159	30,159	30,159	30,159	30,159	30,159	30,159	30,159	30,159
Benefits of pre-payment: pass due accounts		8,475	8,687	8,687	8,687	8,687	8,687	8,687	8,687	8,687	8,687
Elimination of un-billable past due accounts: Bad debt		311,093	318,870	326,842	335,013	343,389	351,973	360,773	369,792	379,037	388,513
Elimination of Financial Costs on past due accounts (Financial cost; Private)		2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Tax Savings from Additional Depreciation of prepaid system over Regular system		18,055	18,055	18,055	18,055	18,055	18,055	18,055	18,055	18,055	18,055
Investment savings on electrical meters	300,000										
Investment savings on electrical meter installation	150,000										
TOTAL SAVINGS / INCOME	450,000	416,447	426,345	434,893	443,655	452,637	461,842	471,278	480,949	490,863	501,024
V. ACTUAL INCOME	3,219,995										
COSTS & INITIAL INVESTMENT	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Investment Pre- Paid Meter	813,000										
System Investment (Hardware and Software)	179,204										
Software Administration(Labour)		7,800	7,800	7,800	7,800	7,800	7,800	7,800	7,800	7,800	7,800
Operation and Maintenance		7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
Income Recognized by disconnection and Reconnection (Fines)		0	0	0	0	0	0	0	0	0	0
Installation of Meters **Utility Labour**	180,000										
TOTAL COSTS	1,172,204	15,300	15,300	15,300	15,300	15,300	15,300	15,300	15,300	15,300	15,300
ACTUAL COSTS	1,266,216										
Flow of net funds	-722,204	401,147	411,044	419,592	428,354	437,335	446,541	455,977	465,648	475,562	485,723
Flow of Accumulated funds	-722,204	-321,057	89,987	509,579	937,934	1,375,269	1,821,810	2,277,787	2,743,435	3,218,997	3,704,720
Flow of discounted funds	-722,204	364679	339,706	315,246	292,572	271,551	252,061	233,988	217,228	201,685	187,267
Flow of Accumulated discounted funds	-722,204	-357,525	-17,819	297,427	589,998	861,549	1,113,610	1,347,598	1,564,827	1,766,511	1,953,779
RESULTS OF CASHFLOW											
10 years NPV	$1,953,779										
10 years IRR	57.02%										
Pay Back Period (in years)	1.63										
SENSIBILITY PARAMETERS / DATA ENTRY											
DISCOUNT RATE	10%										
TOTAL NUMBER OF PRE-PAID METERS TO INSTALL	7,500										
AVERAGE MONTHLY POWER USAGE PER METER(KWH)	367										
AVERAGE RATE PER KWH (US $)	0.1794										
AVERAGE ANNUAL INVOICING	$5,925,582										
INVOICING INCOME IN NORMAL TIME PERIOD	$888,837	15%									
ANNUAL PAST DUE ACCOUNTS	35%	Total									

BAD DEBT PERCENTAGE(OVER THE ANNUAL PAST DUE ACCOUNTS)	$311,093	Bad Debt/Theft
ANNUAL BAD DEBT AMOUNT	$577,744	5.25%
PAST DUE ACCOUNTS TO BILL	3.50%	
FINANCE COSTS	2	
ANTICIPATED TIME FOR BILLING OF SERVICE (IN MONTHS)	3	
ANTICIPATED TIME FOR TO COLLECT PAST DUE ACCOUNTS	5	
PRE-PAID METER COST(GEMINI,80A)	$98	80%
PRE-PAID METER COST (From 25,200A)	$150	20%
ELECTRICAL METER COST	$40	
Pre-paid meter investment	$813,000	
Total investment pre-paid meters	$1,172,204	
Investment savings in electrical meter	$300,000	
Investment savings in electrical meter installation	$150,000	
Total net initial investment	$722,204	
Additional Annual Depreciation for Pre-paid System(data)	$72,220	
Corporate Tax Rate	25%	
Prepaid System Administrator (Gross monthly Salary)	$600	
Average unit cost of" reading and distribution of invoices"	$0.25	
Number of annual reading by user (6 or 12 only)	12	
Average unit cost for "disconnection and reconnection"	$24	
Average number of disconnect and reconnect by user	8.00%	
Average unit cost for maintenance of meter	$10.00	
Percentage of meters in maintenance by year	10%	
Average annual administrative savings on pre-paid meter		
Average Annual Fine or Charge for "disconnect and reconnect"		
Installation costs for pre-paid	$24.00	
Installation costs for electrical meter	$20.00	
Inflation (US $)	2.50%	


Discounted Cash Flow
(Repayment Period)
2,000,000
1,500,000
1,000,000
500,000
0
-500,000
-1,000,000
1
2
3
4
5
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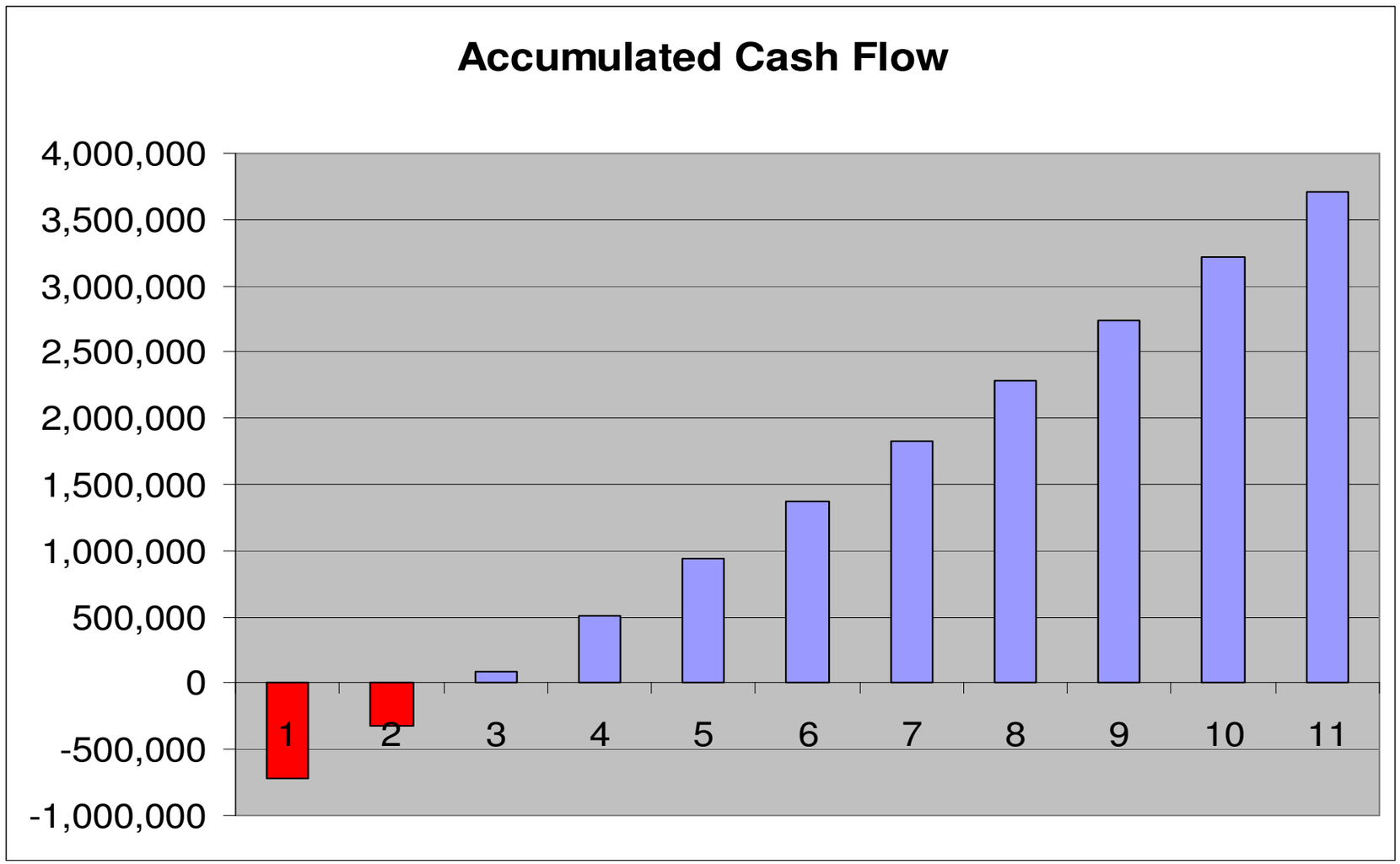
7
8
9
10
11


Accumulated Cash Flow
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
-500,000
-1,000,000
1
2
3
4
5
6
7
8
9
10
11