



USAID
FROM THE AMERICAN PEOPLE

SARI / Energy

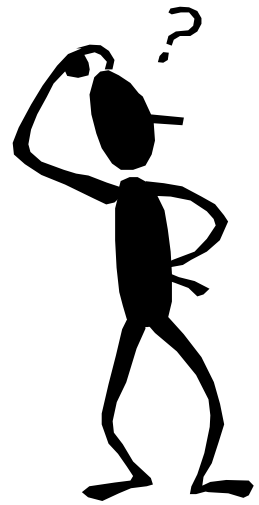
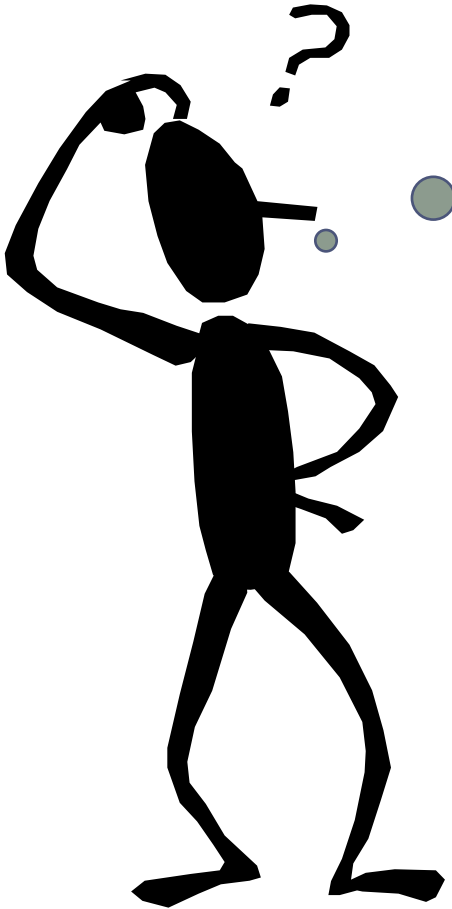
Software functional features of Energy Meter
by
N.K.Bhati

A specifically designed programme for

Da Afghanistan Breshna Sherkat (DABS)
Afghanistan

What s/w has
to do with
energy
meter???

I know a bit !



Energy Meter S/W features

Course objectives.

Familiarize you with

- Basic software features '*built in*' modern energy meters.
- Some definitions.
- Some derivations or implementations
- there are no standards for S/W yet. Only CBIP (new) publication no. 304 (tech. report 88) specifies a few requirement.

Functional comparison

EM Meter	Static meter
KWH or Trivector	<p>Monitoring</p> <p>Instantaneous parameters like V, Amps ,KW, KVA, PF(phase wise and 3 phase), Energies KWH, KVAh, KVARh lag/lead, Registers for import and export metering;</p>
	<p>Additional Monitoring</p> <p>Frequency, phase sequence, line to line voltage, N current, unbalance in voltage and current</p>
	<p>Billing related parameters (Real time clock based)</p> <p>Demand, Max demand, Cumulative demand and demand reset count, Max demand occurrence date and time , monthly average power factor.</p> <p>Tariff registers (TOD or TOU) and Billing Registers, History of billing up to 12 months,</p>



EM Meter	Static meter
	Load survey/ parameter profiling, multi parameters, upto 180 days or more
	<p>Tamper detection and recording with occurrence and restoration info and related parameters and energies</p> <p>Forwarded and estimated energy in case of selected tampers</p>
	Can measure N current, apply MF,
	Accuracy enhancement: internal sensors and external CT/PT, High accuracy at affordable prices, no wear and tear, long term performance
	Communication...Electronic reading, AMR / RMR thru various communication medias, protocol implementation
	Multi parameter display

EM Meter	Static meter
	Parameter configuration of displays, Tariff TOD registers, timing, MD type and DIP, Load survey parameters and period, tamper detection thresholds,
	Security of internal functions/ configuration
	Self diagnostic, power On hours, interruptions info
	Facilitate on site testing Calib LED, Hi resolution energy display
	Load control thru Relays or load Switch (DSM)
	Prepayment metering, managing energy account
	Total or fundamental energies
	CT/PT error compensation, summation metering



Energy Meter S/W features

- Metering engineer and business managers view point
- Unlike old FWM meters, Most Static meters are intelligent instruments.
- A static energy meter is as powerful as its s/w features.
- Generally operation of the meter is simple though s/w implemented may be complex, its features are given in operation manual.
- Meter s/w is driven from the planned Metering System implementation, application and customer specifications.
- Same meter H/W may have different s/w to be suitable for different applications.

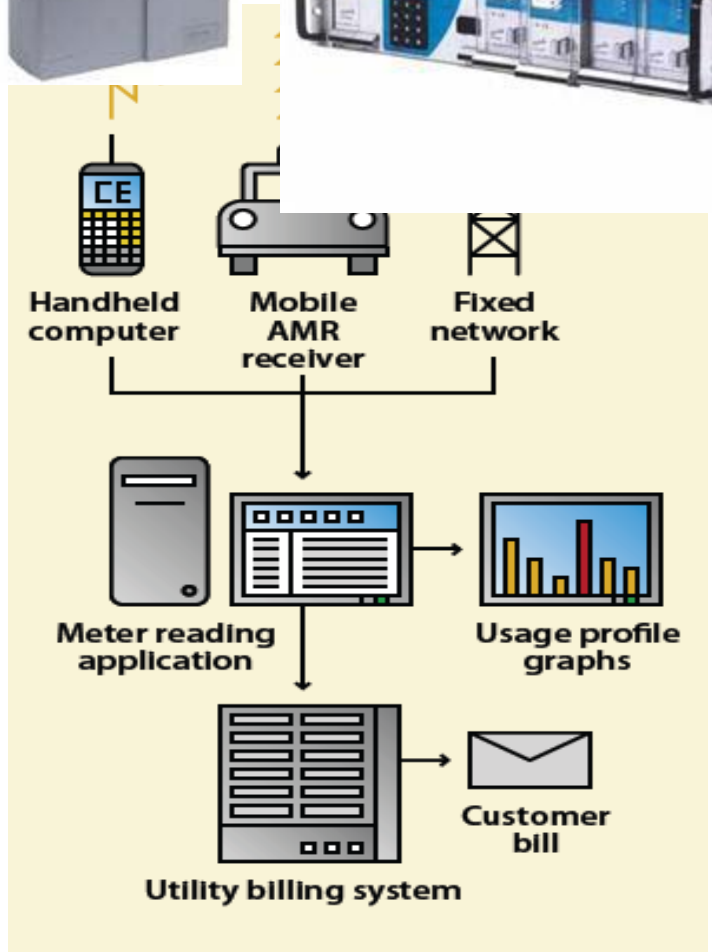
Energy Meter S/W features

- The Metering system implementation has 3 basic elements
 - The Consumer Energy Meter (CEM),
 - The Meter Reading Instrument (MRI),
 - The Base Computer System (BCS) for information management, setting up configuration of meters etc,
- Appropriate s/w is required for each of these to get application delivered.



Meter Reading

- **By visiting each meter,**
 - Uses a MRI , a handheld computer/PDA, may have barcode reader, printer , optical reading cable
 - Manual reading and recording, or electronic reading (full, selective or local parameters)
 - Route Master and spot Billing /cheque collection
- **Remotely (Wireless)**
 - Low Power Radio.. walk-by or drive by system
 - MRI with wireless, polls meters and reads
 - Fixed wireless system, mesh network, data concentrators
 - Telephone Networks GSM/GPRS



Metering system information management

- Meter management

- Meter and consumer data, configuration, CT/PT Ratio, MF, read meters thru MRI /direct , configure meters, tariffs, RTC , reset tampers, extract readings, load survey, tamper info etc.
- Suitable for some no. of meters, mfr. Specific , stand alone application
- Generally not a RMR, information analysis and management tool
- Suitable for data viewing, printing, billing, data conversion
- Example PRI M cubed s/w

Metering MIS and Utility Management

- Supports AMR/RMR, direct data thru MRI , file transfer
- multivendor metering data ; data aggregation and management
- Web based, large database for customer info and billing, load profiles, tamper and related info.
- Supports all meters, consumer and system meters.
- client/server Architecture, web based
- Reports for Billing, load forecasting, engineering info,
- Customer Relations Management (CIS and CRM)
- GIS, asset management, outage management

- Examples PRI Integrator, ITRON IEE MDM, SAP ERP, CRM, Billing, and Energy Data Management.



Energy Meter S/W features

- Basic functions
 - Electrical measurement
 - Data processing and recording in NVM
 - Displays
 - Communication
 - Pulse I/O or load control relays.
 - Real time clock
- Not all functions are available in all type of meters



Energy Meter S/W features

- **Derived functions:**
 - Various energy registers.
 - Demand measurement.
 - Tariff and billing information.
 - Data storage: Load survey or parameter profiles
 - Other electrical parameters.
 - Tamper detection and logging.
 - Configurability support.
 - Communication and Data security.
 - External CT/PT error compensation

Energy meter.... basic functions

Electrical Measurement.

- Phase wise Voltage, line current, power, pf.,
- Sum of three phase active power, reactive power (*Reactive leading is generally taken as negative*)
- Average instantaneous power factor
(Be careful , what is the definition of average instantaneous pf ?)
- Apparent power
- Power and energy measurement may be Total or fundamental basis.



Energy meter.... basic functions

- Power
 - $P = v.i$
 - or $P_f = V_f I_f \cos\Phi_f$
 - If measurement is on fundamental basis then internally Fourier analysis will be applied to derive fundamental components.
- Energy = $\int P.dt$ or $\sum P.\Delta t$ where Δt is a fixed interval of measurement.
- Energy is stated in units of **Wh (Watt-hours), kWh or MWh.**
- Internally meter s/w will apply calibration, correction for sensor errors and scaling and MF in case of CT or CT/VT meters. Also calibration LED pulse o/p will be driven.

Energy meter.... basic functions

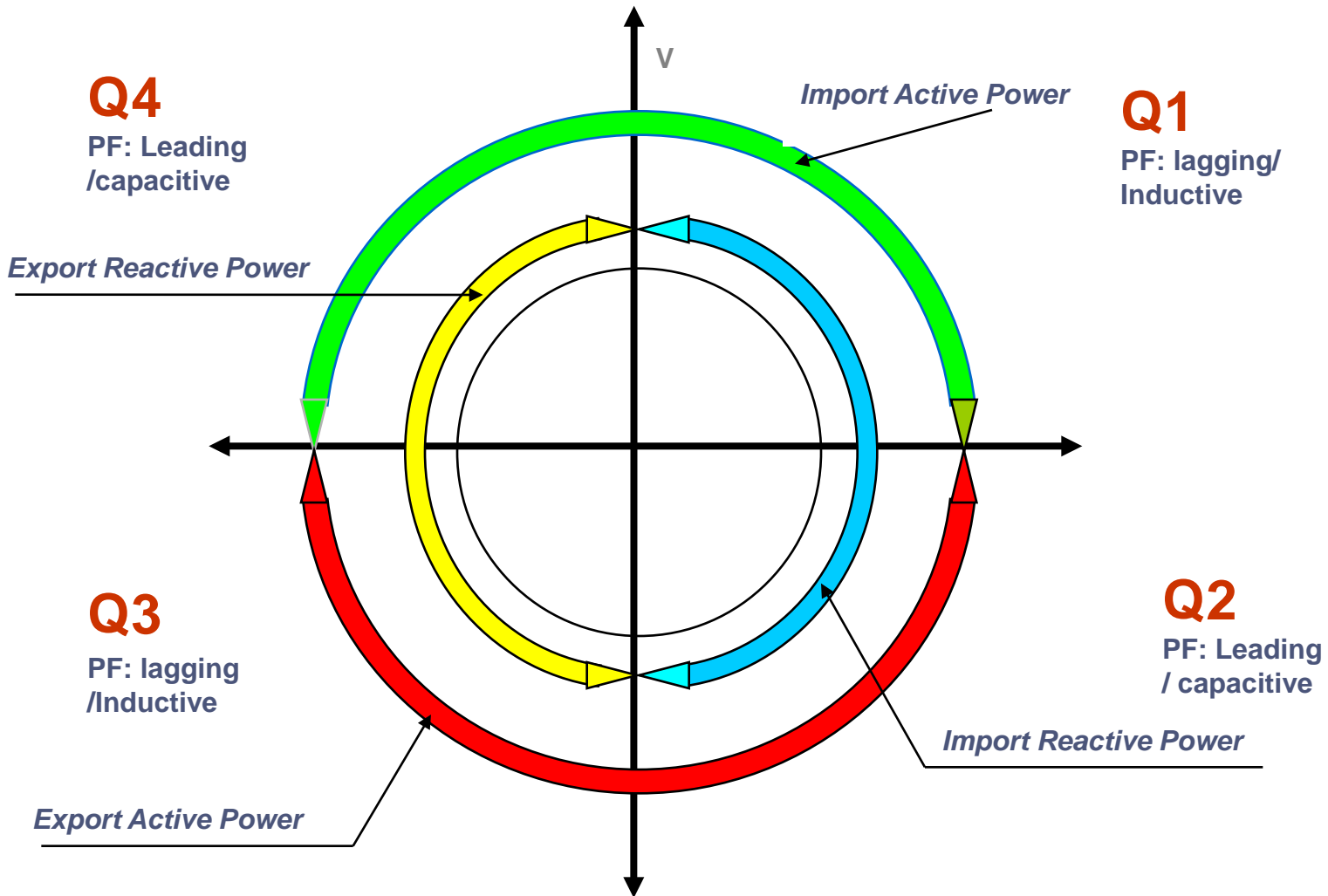
- Apparent power $VA = \sqrt{W^2 + VAr^2}$
 - Where W is net active power and VAr is net reactive power

- Power factor:

$$pf = \text{active (real) power} / \text{apparent power}$$
$$= W / VA$$



Power Flow Quadrants: IEC62053-23



Energy meter.... Derived functions

Energy registers

Mainly 4 or 5 types

- Active (kWh) export
- Reactive (kVArh) import
- Reactive (kVArh) export
- Active (kWh) import
- Apparent (kVAh)

972535



- However reactive registers definition varies from utility to utility and depends on tariff
- *kVArh Lag (kW import) (Q1), kVArh Lead (kW import) (Q4), kVArh Import (Q1+2), kVArh Export (Q3+4), kVArh Import and Export (all four)*



Energy meter.... Derived functions

- Apparent Energy: Depends on tariff... for import meters

Lag only: The kVAh register accumulates metered energy only when the kWh is imported. In lagging power factor quadrant (Q1).

In leading pf, (Q4) kVAh = kWh

(This is rewarding the consumer for providing capacitor, but ??)

Lag+lead: The kVAh register accumulates metered energy only when the kWh is imported. In both lagging power factor quadrant (Q1) and leading power factor quadrant (Q4).

$$VA = \sqrt{W^2 + VAr^2}$$

Energy meter.... Derived functions

Other register implementation:

- Fraud register.
- Forwarded register
(Net forwarded or phase wise forwarded.)
- Estimated consumption register

Energy meter.... Derived functions

- Demand: average power required during a defined time, normally called Demand Integration Period (DIP)

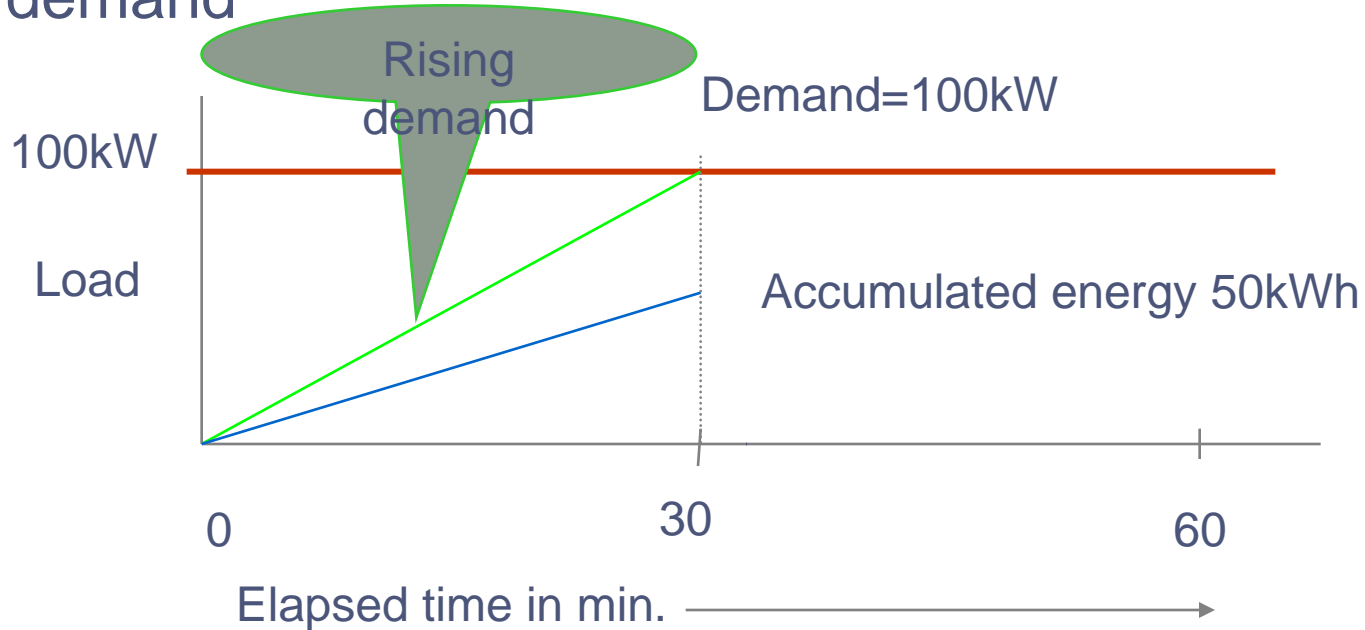
$$\text{Average Demand} = \frac{\text{Energy consumed in DIP}}{\text{DIP time (in hours)}}$$

- Rising demand:

$$\text{Rising Demand at elapsed time } t1 = \frac{\text{Energy consumed in time } t1}{\text{DIP time (in hours)}}$$

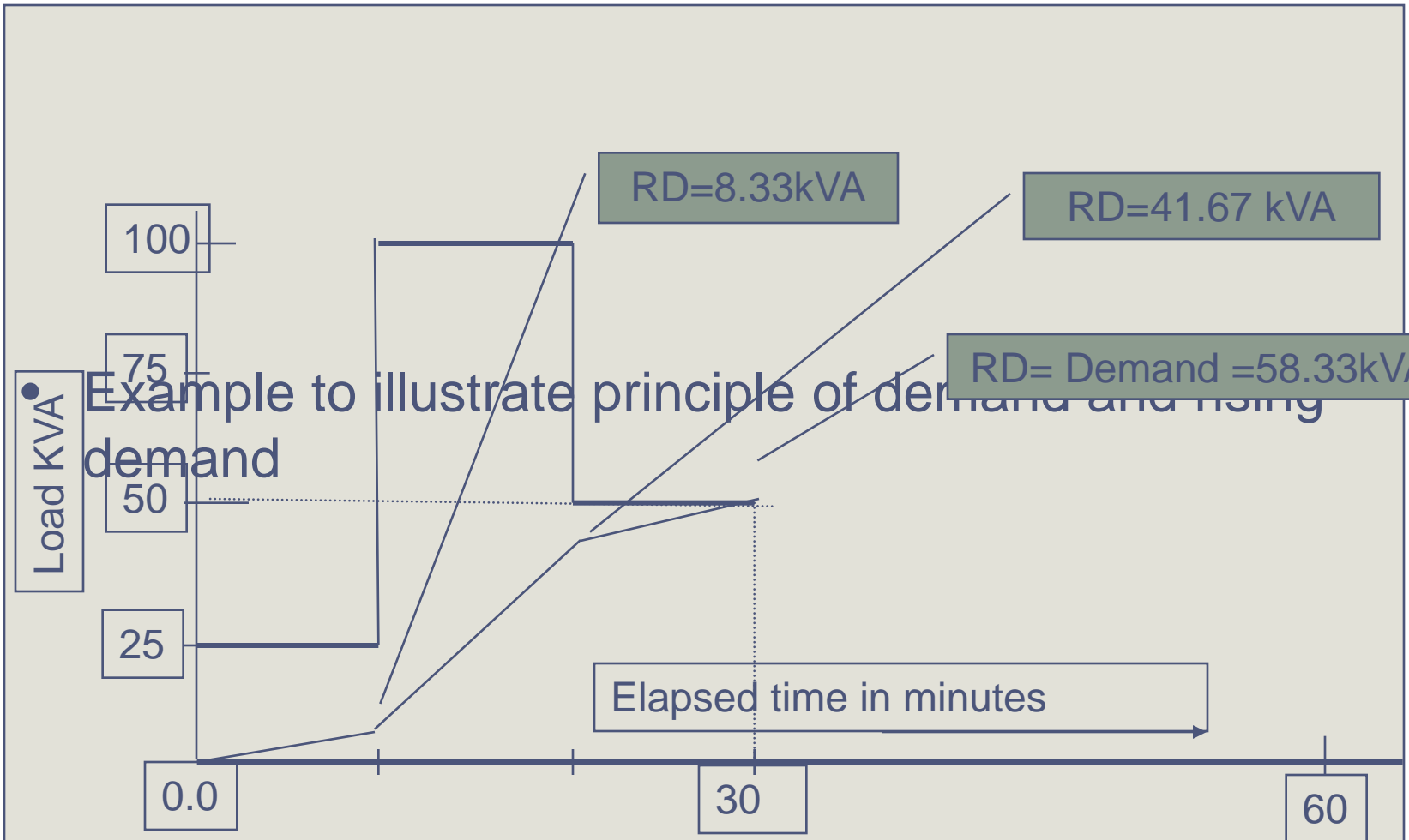
Energy meter.... Derived functions

- Example to illustrate principle of demand and rising demand





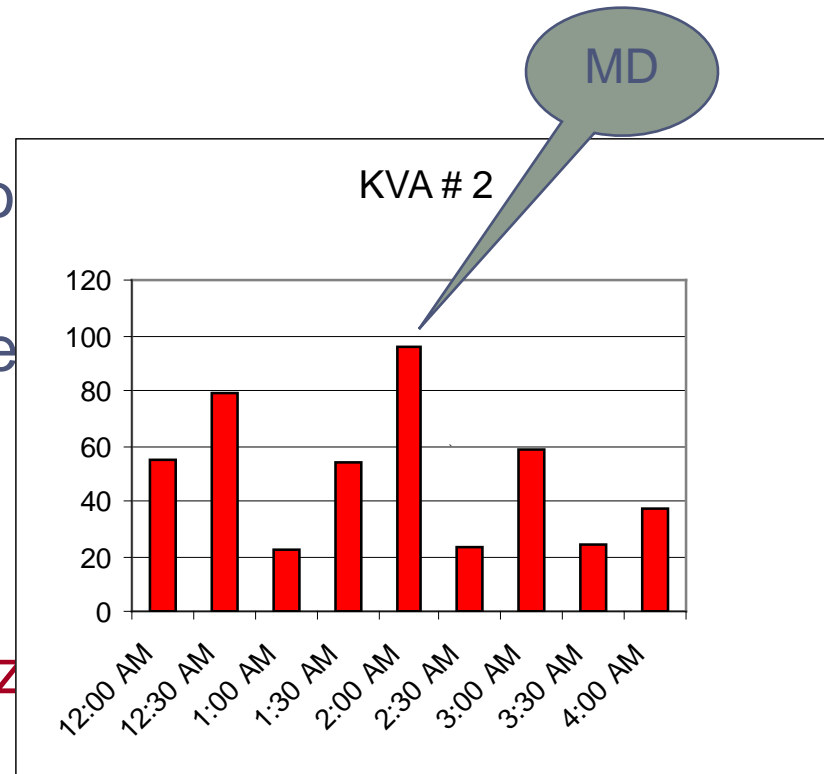
Energy meter.... Derived functions



Example to illustrate principle of demand and RD

Energy meter.... Derived functions

- Maximum Demand (MD) register: is defined as the largest amount of power drawn (average demand) over a defined DIP since the meter was last read/ or demand reset
- It is common to use kVA as a measure of MD rather than kW since kVA is used to define the size of conductors and transmission hardware.
- MD occurrence date and time is also recorded.





Energy meter.... Derived functions

- Primary objective of meter is to measure energy used and bill to consumer based on applicable Tariffs.
- Tariffs are of two types.
 - Fixed rate (may be slabs based) or multi rate based on time of use.
 - May be two (normal and peak or surplus time) or 4 or 8 TOU registers.
 - In some countries STOD is used,
- Example
 - TOD 1 - 6 am to 9 am, TOD 2 -9 to 6 PM.
 - TOD 3 – 6 PM to 12:00, TOD 4 -12 to 6am
- MD register also has bill register and one register is maintained for 24 hrs. known as Universal MD register



Registers

continuously

kWh register

kW MD register

kVArh register

RTC based

kWh TOU1

kWh TOU2

kWh TOU3

kWh TOU4

kW MD TOU1

kW MD TOU2

kW MD TOU3

kW MD TOU4

On billing action

kWh Bill register

kWh Bill TOU1

kWh Bill TOU2

kWh Bill TOU3

kWh Bill TOU4

kW MD Bill register

kW MD Bill TOU1

kW MD Bill TOU2

kW MD Bill TOU3

kW MD Bill TOU4



Energy meter.... Derived functions

Billing Rate/Maximum Demand Registers

- On each Bill action, main registers are copied to bill registers.
- **Billing actions:**
 - On fixed date and time.
 - Manual billing by button
 - Thru MRI.
- **On Billing action, MD register is copied to bill register and reset automatically.**
- Most of time, there is Cumulative MD register also, each time demand is reset it is added into this register. Also a Max Demand reset counter is kept . (why?)

Energy meter.... Derived functions

- **History registers.**
 - Some customers ask for histories of Bill register for selected or all type of registers for 3 or 6 months.
- **Average monthly power factor:**
 - This is defined as $\text{kWh consumed} / \text{kVAh consumed}$ and used for penalty or incentive.

Energy meter.... Derived functions

Load Surveys

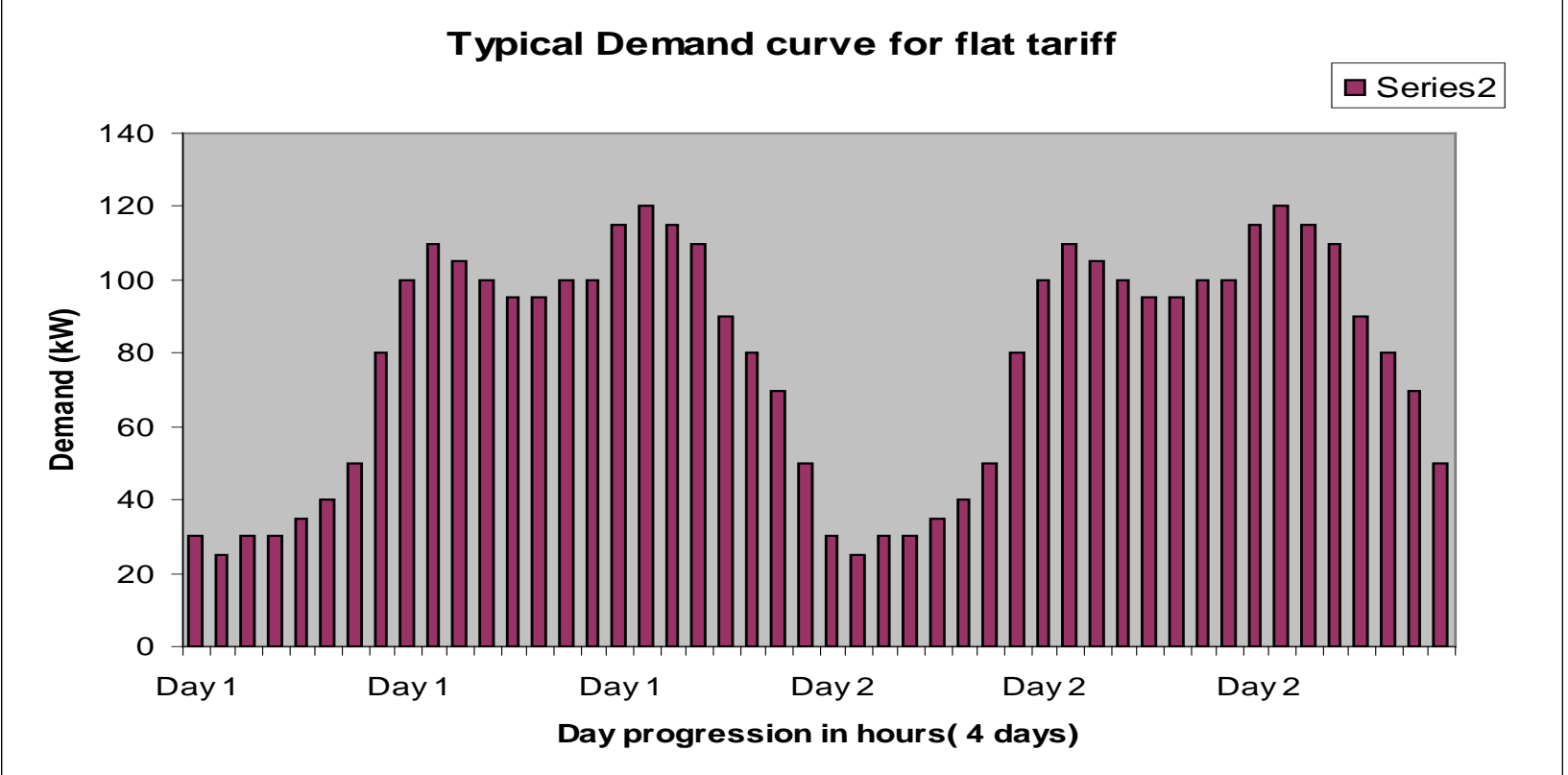
- Record of how energy consumption has varied over time.
- Average consumption/ demand for every SIP/ DIP stored.
- 48 or 96 records per day., for 30/45/60 days.
- Data may be for 1 to 4 parameters.
- May be 10/12/16 bit resolution
- This requires large memory size,

Typical parameters for load survey include:

- kW import/export, kVA import/export, kVAr import/export.
- These days, many customer ask for even other parameters also to be recorded, then it is called as 'parameter profile'
- Time stamped info on events, such as power on/ power off, RTC/ battery status, self diagnostic status etc.

Energy meter.... Derived functions

- A typical load survey



Energy meter.... Derived functions

Other electrical parameters.

- Many Meters has capability to measure, display and record many other parameters also like
 - Frequency,
 - Phase to phase voltages,
 - Angle between voltage phases,
 - Harmonic energy
 - Phase sequence
- Some meters are capable to give parameters such that complete vectorial analysis can be done.

Tamper detection capability of electronic meters



Energy meter.... Derived functions

What is a tamper?

- An intentional change in electrical parameters such that it gives an advantage to the customer by registering less energy than actually consumed

Tamper detection and logging:

- Meter analyses the electrical parameters and their relationships to make a judgment whether this is a situation which may happen due to normal load condition or is artificially caused.
- Tamper detection logics can be as powerful as application knowledge and its appropriate implementation in s/w. some tamper detection needs special h/w support also.
 - 4th Current sensor and support circuit,
 - Magnetic field detection .
 - Meter cover/ TB cover open detection

Energy meter.... Derived functions

Commonly logged tampers

- Missing potential
- Invalid voltage
- CT reversal
- CT short or CT By-pass, CT open
- Wrong phase association
- Current unbalance
- Voltage unbalance
- Neutral disturbance ,
- Magnetic tampers etc
- Power on /off

S/w must be capable to differentiate between system conditions and actual tampers

Tamper proof or tamper evident?????



Tamper detection and logging

- Tamper detection is generally allowed some time called persistence time Pt.(60 to 300 sec)
- There are threshold values for V, I etc below which tampers are difficult to detect.
- Tamper has two event
 - Occurrence
 - Restoration
- Tamper recording is done as events with following info
 - Date and time of occurrence and restoration,
 - type of tamper,
 - Instantaneous parameters when tamper event has occurred



Tamper detection and logging

- Tamperers are recorded in separate records. There may be a single folder or multiple folders called compartments.
- These may be recorded as FIFO with roll over or stay put type.

Analysis Reports

Meter No: **PH0271** Location: **CTR** CTR: **1** E.M.F.: **1**

Tamper Details Keys File not found

Tamper Supported

- R-Ph CT reversal
- Y-Ph CT reversal
- B-Ph CT reversal
- CT open
- CT short
- Load Imbalance
- R-Ph Missing Pot.
- Y-Ph Missing Pot.
- B-Ph Missing Pot
- Voltage Imbalance
- Neutral disturbance
- Magnet
- Power failed

Tamper Description	TampDate	Status
CT open	30/04/2003 17:02	Occured
CT open	02/05/2003 10:39	Restored
Voltage Imbalance	03/05/2003 10:49	Occured
CT short	03/05/2003 10:55	Occured
Voltage Imbalance	03/05/2003 11:12	Restored
R-Ph CT reversal	03/05/2003 11:13	Occured
R-Ph CT reversal	03/05/2003 11:33	Restored
CT short	03/05/2003 11:33	Restored
CT open	03/05/2003 11:39	Occured
CT open	03/05/2003 11:45	Restored
CT open	03/05/2003 12:13	Occured
CT open	03/05/2003 12:20	Restored
Magnet	03/05/2003 14:36	Restored
Magnet	03/05/2003 14:37	Occured
Magnet	03/05/2003 14:38	Restored
Magnet	03/05/2003 14:38	Occured
Magnet	03/05/2003 14:39	Restored
Magnet	05/05/2003 11:44	Occured
Magnet	05/05/2003 11:45	Restored
Magnet	05/05/2003 11:45	Occured
Magnet	05/05/2003 11:46	Restored
CT short	05/05/2003 11:47	Occured
Magnet	05/05/2003 11:47	Occured

Event log with date & time

Snapshot

Snapshot	Value
Voltage-R	6.0325 kV(R)
Voltage-Y	6.35 kV(Y)
Voltage-B	6.4135 kV(B)
Act. Current R	-0.99 Amp(I-R)
Act. Current Y	1.0296 Amp(I-Y)
Act. Current B	0.99 Amp(I-B)
P.F. R-Phase	0.99
P.F. Y-Phase	0.99
P.F. B-Phase	0.99
Wh(E)	3200
Wh(I)	88400

Summary

Tamper	Count	Cum. Time (ddd hh:mm)
B-Ph Missing Pot	1	000 00:16
R-Ph CT reversal	1	000 00:19
Voltage Imbalance	2	000 00:23
CT short	3	000 03:19
CT open	4	002 12:19
Magnet	9	000 00:04
Power failed	10	022 10:09

Read Me

This Screen shows the tamper existing in the meter since last tamper reset or since meter installed whichever is later. The check list shows the total tampers supported by meter. The upper grid shows the

Snapshot of electrical parameters



Tamper detection and logging

- A few designs have tamper deterrence features such as recording energy at I_{max}.
- A few designs may have forward recording or deficiency metering.
- A few designs have tamper isolation specially Neutral isolation.
- Not all tampers can be detected like h/w modifications,

Energy meter.... Configurability support.

- **Meter s/w allows many features to be configured.**
 - Ptime/ threshold for tamper detection.
 - Number and type of parameters to be recorded in Load surveys
 - DIP/SIP time
 - Apparent energy and reactive energy calculation basis, generally called energy definitions.
 - Tariffs related parameters like No. of TOU registers, their timings
 - Bill dates, billing action, and MD reset methods .
 - No. of Histories of bill registers,

Energy meter.... Configurability support.

- The configurability must be secure and an audit trail must be kept by the meter s/w.
- These are done thru meter transactions.

Energy meter s/w .. Security

- Meter s/w must have adequate security against any unauthorised
 - change in s/w configurations.
 - Reading of data recorded.
 - Change of calibration data.
 - Writing into memory which may disrupt functioning or recorded data
- This is done thru authorised transactions.
 - Several techniques of authenticated message processing like pass word and advanced methods.
- Each transaction processed is recorded for audit trail and is transferred to BCS system along with meter reading electronically.



Energy meter s/w ... Communication and Data security.

- Most meters support one or two communication ports.
- One port is normally optically isolated port, using two signals (Tx and Rx.) serial data transfer at baud rates upto 9600 bps. Mostly simplex communication is used.
- Communication ports may have proprietary or 1107/ANSI form factor.
- S/w protocol may be proprietary or as per some of new standards like 1107/ DLMS etc.
- Information is generally packet based.
- Some meters allow ASCII protocol for reading instantaneous parameters and registers etc.



Energy meter s/w ...Communication and Data security.

- Other comm. port is normally isolated serial port RS 232 or RS 485 port.
- Work is being done for communication over power lines too. Low power radio is being used.
- The protocol may be as per customer specification. Advanced protocols may include EDC.
- This is used in industrial or in panels etc substation monitoring etc.
- This port is also used for Remote reading of meters thru PSTN dial up lines or GSM modems. In this case compatible s/w needs to be provided.

Energy meter s/w ...Communication and Data security.

- Once meter is manufactured its security is locked, means no change can be effected with out proper and secure method.
- Data transferred from Meter to MRI or on line reading shall be secure, to indicate any change in data intentionally or unintentionally (any corruption).
- Most meters will use some form of message authentication.
- Base computer system will check and validate data before using it,

Energy meter s/w ...Communication and Data security.

- Meters are supplied with meter specific 'keys' which are used for data validation.
- These keys are also used for preparing transactions for effecting any change in the meter, like changing any configuration parameter etc.
- A proper management and safe custody of meter keys is very important and utility engineers must give required attention to this.

Energy meter s/w ...Communication and Data security.

- Many designs allow several levels of access to meter data.
- Selected levels can access to certain allowed data.
- This is managed thru access codes and multiple levels of passwords.
- Each user can define his own password.

Energy meter s/w .. Advanced features

- External CT /PT error compensation.
- Scaling meters for different CT PT ratios.
- Power quality parameter monitoring and recording.
- Summation metering.
- Traction metering.
- Transformer loss compensation.
- Vsquared hours or DASH Metering.



Energy meter s/w...

Some self diagnostics are included like

- RTC battery voltage,
- RTC health,
- Lamp test of display,
- memory test,
- A few of these are really useful, others are superfluous
- Some meters support high resolution displays for meter testing (resolution of 0.001Wh)



Energy meter s/w...RTC

- RTC is required to implement all time based functions, like MD, LS, billing , TOD and event logging.
- Meter displays date and time and also appended in electronic reading.
- Quartz crystal controlled Real Time Clock with battery back up is used.
- Battery life of >10 years in circuit and 2 years in box .
- Time is read every power up and periodically from RTC.
- Once time is set meter maintains it.
- Some meters allow time correction in circuit thru MRI in small range.
- Time can be set only by special transactions.



Energy Meter S/W..... Displays

- Meters have large amount of data and can display several parameters , as configured.
- Prudence needs to be applied to what needs to be displayed and why ?, who will use it and how?
- A large number of displays will be confusing and will lead to mistakes or frustration, large reading time etc.

Energy Meter S/W..... Displays

Simple form of displays are LEDs.

- In most meters we find one /two or five LEDs.
 - Activity indicator
 - Calibration LED.
 - Phase indicators 1 or 3 .
 - Tamper LED.
- In some low cost meters electromechanical counter is used.

Energy Meter S/W..... Displays

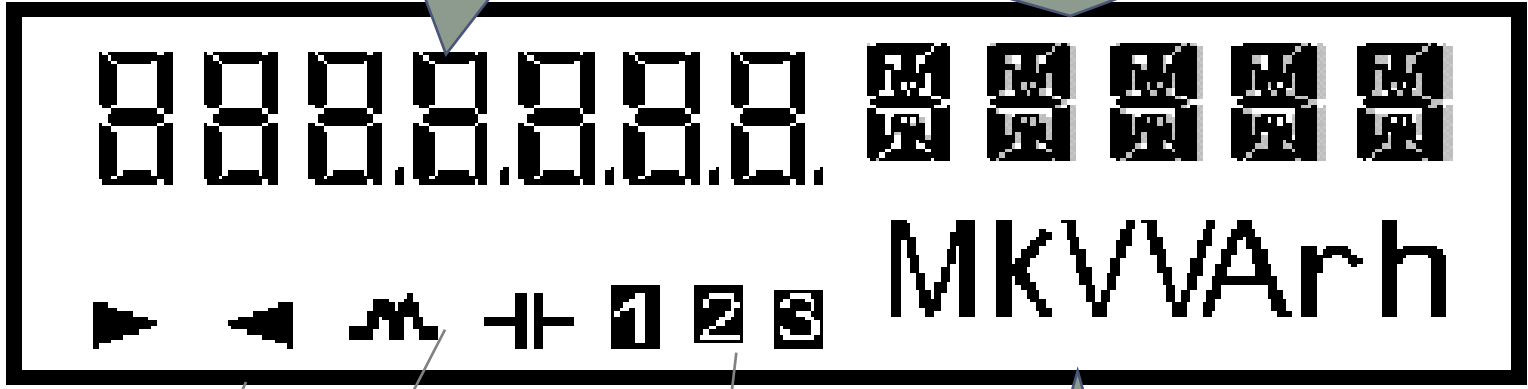
- Intelligent meters have LED or LCD displays.
- Displays may be dot matrix or character based.
- Generally displays are mix of 7 segment, star burst and legends.



a typical LCD display

7 digit 7 segment numeric display

14 segment alphanumeric



Import Export indicator

Lag lead Pf

Phase status indicators

Unit legends

Energy Meter S/W..... Displays

- Meters display information in two modes:
- Auto display: A sequential display with a fixed On and off time. Number of parameters can be configured.
- Manual display thru buttons: one or two buttons for scroll up or down.
- In some cases 4 buttons are used and page formatted displays are given. Left and right buttons used for page selection.

Displays

- **LAMP TEST**

- In this display, all the segments of the LCD are lighted up to confirm the proper working of the display LCD.

- **DATE**

- This display shows the Current Date in the meter (based on the real time maintained by meter clock called RTC) in DD:MM:YY format.

- **REAL TIME**

- This display shows the Current Time in the meter (based on the real time maintained by meter clock called RTC) in HH:MM:SS

Energy meters..... s/w features

- Some meters provide features of
 - Load control.
 - Self billing.
 - Dial in on events.
 - SCADA RTU function.
 - Max demand control function.
 - Wave form analysis and harmonics measurement.
 - Some new meters are available with Ethernet and can be web enabled.



Energy meter advanced software implementations

- Rack based meters with multiple meter modules, with one common meter function controller, summation based on pulses and in real time communication, on line communication with external world .

Energy meters.... s/w features

- What more do you expect from a little meter?
- If you can imagine and specify, some one will do it. Its intelligence gives it the capability to do so. Of course one will need to pay for it.
- Any ideas??



Any questions please???

- In case you have any questions in future please feel free to write to

nandkishore.bhati@ymllabs.com

We will try our best to answer your queries.

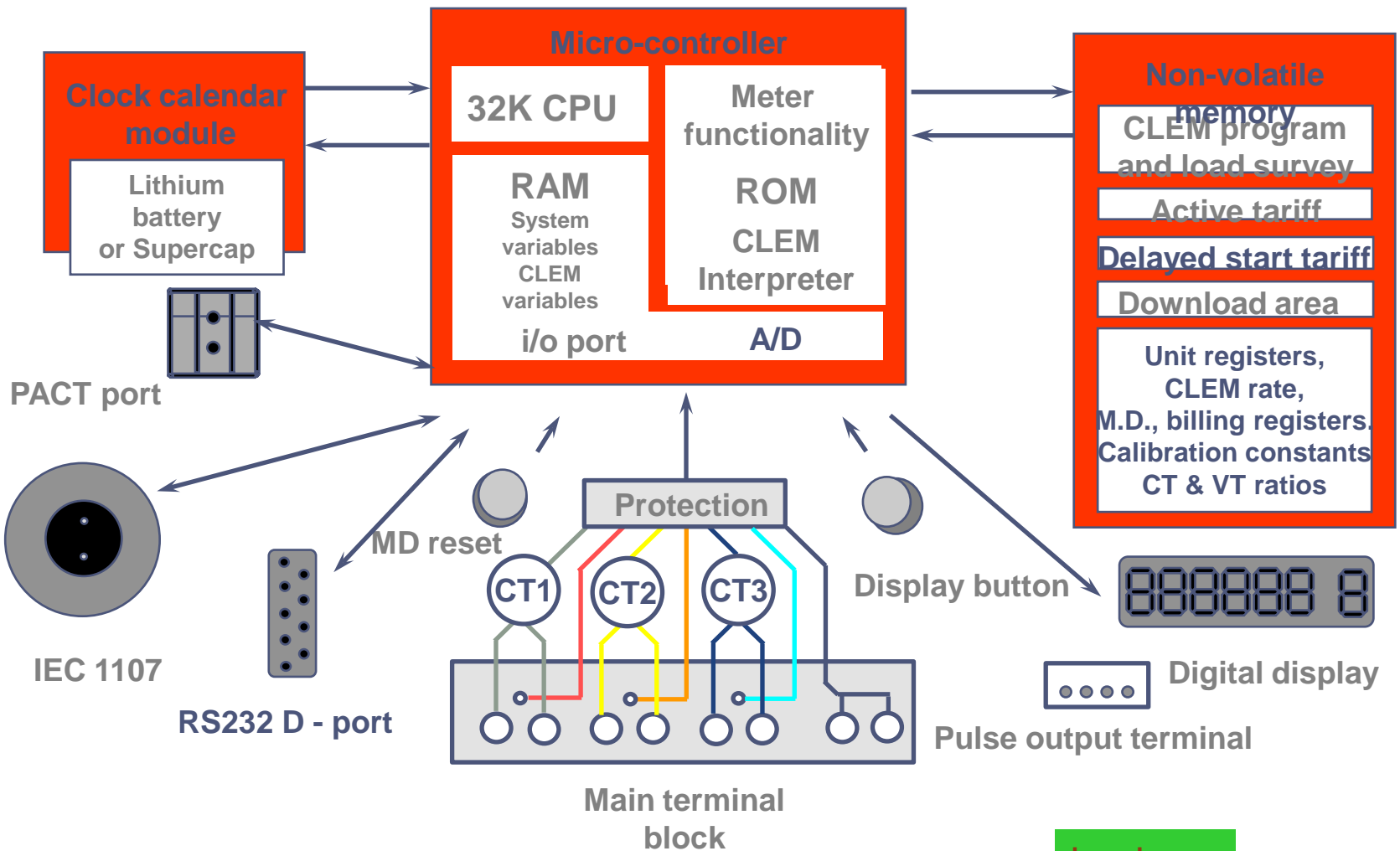


USAID
FROM THE AMERICAN PEOPLE

SARI / Energy

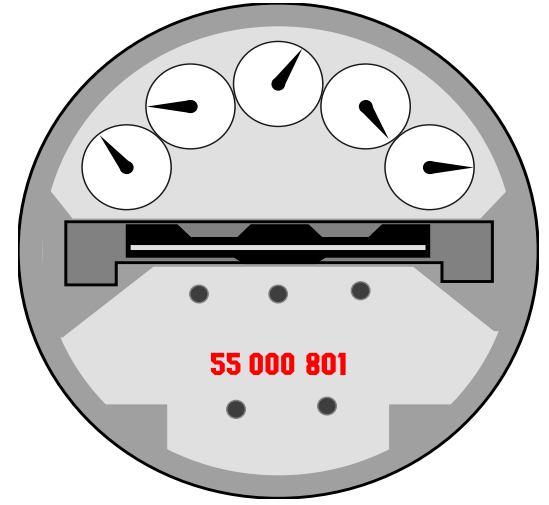
THANK YOU!

Energy meter ...intelligence



What is an energy meter ?

To the **metering engineer**, it is a **measuring instrument** for measuring the flow of electrical energy.



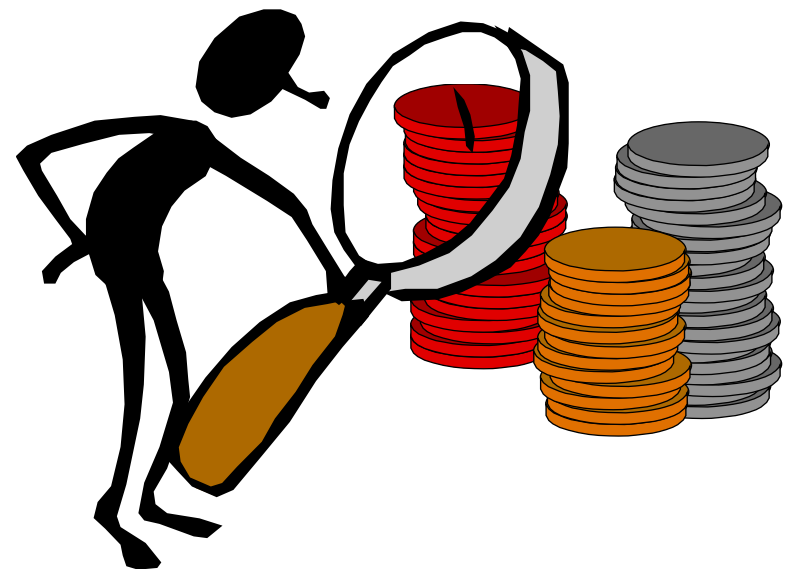
[back](#)



What is an energy meter ?

To the **business manager** it is a small, albeit important, element of a larger **Revenue Management System**

[back](#)





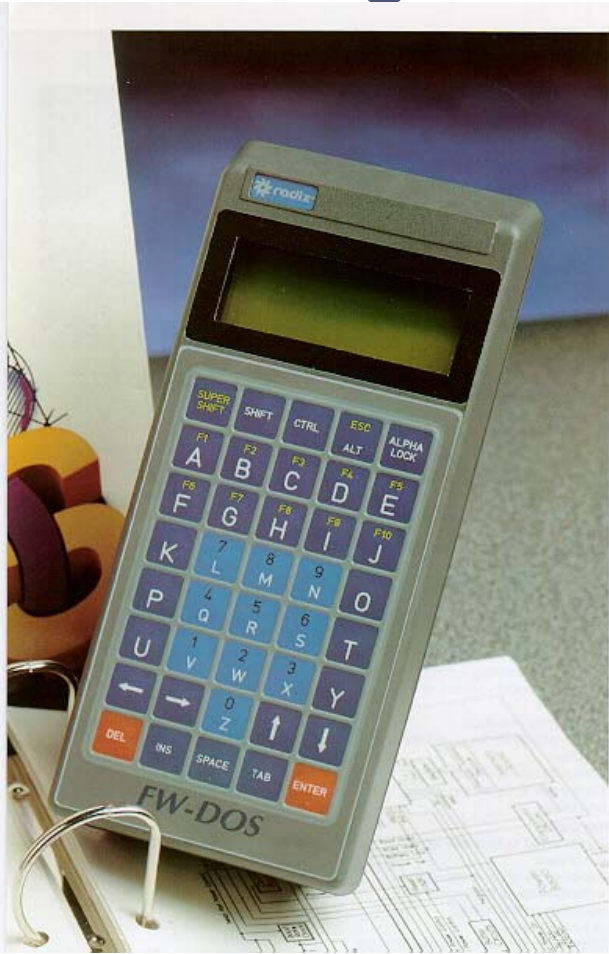
Intelligent Energy Meter



[Back](#)



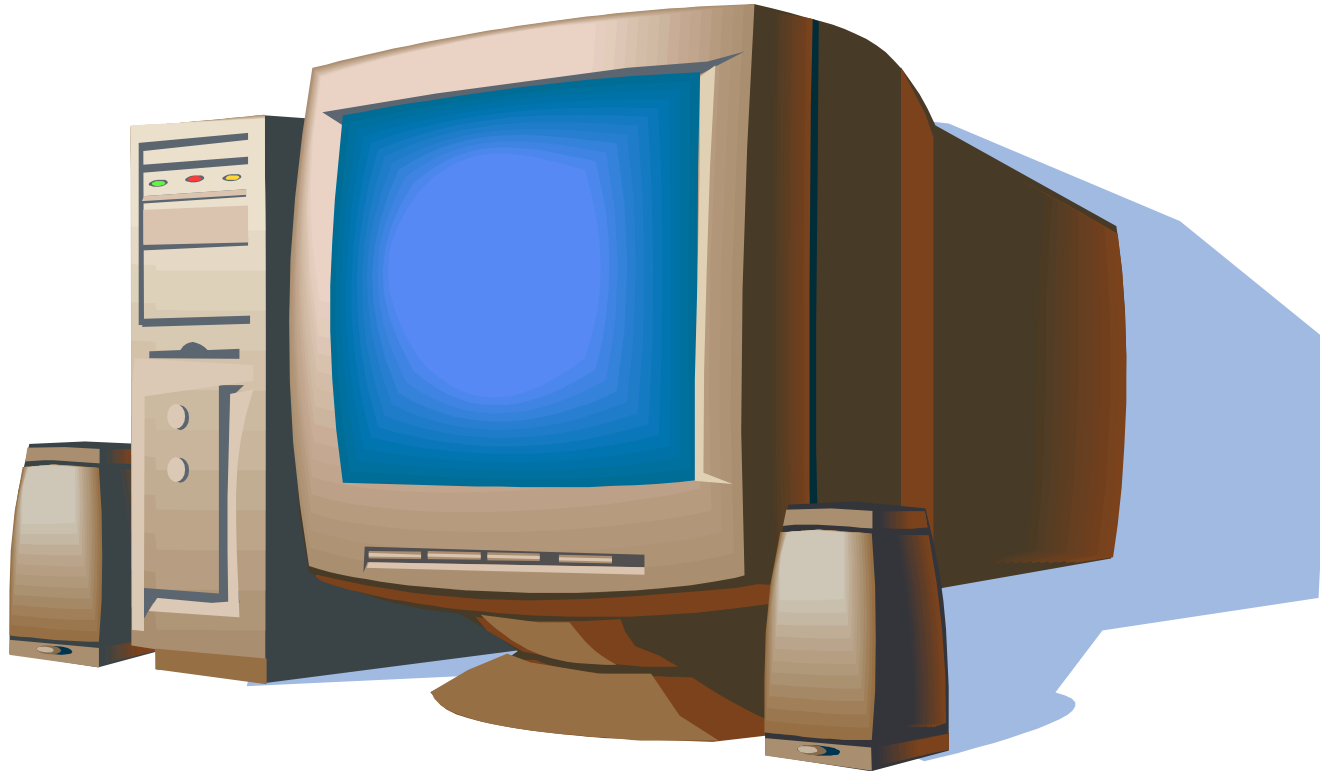
Meter Reading Instrument



[back](#)

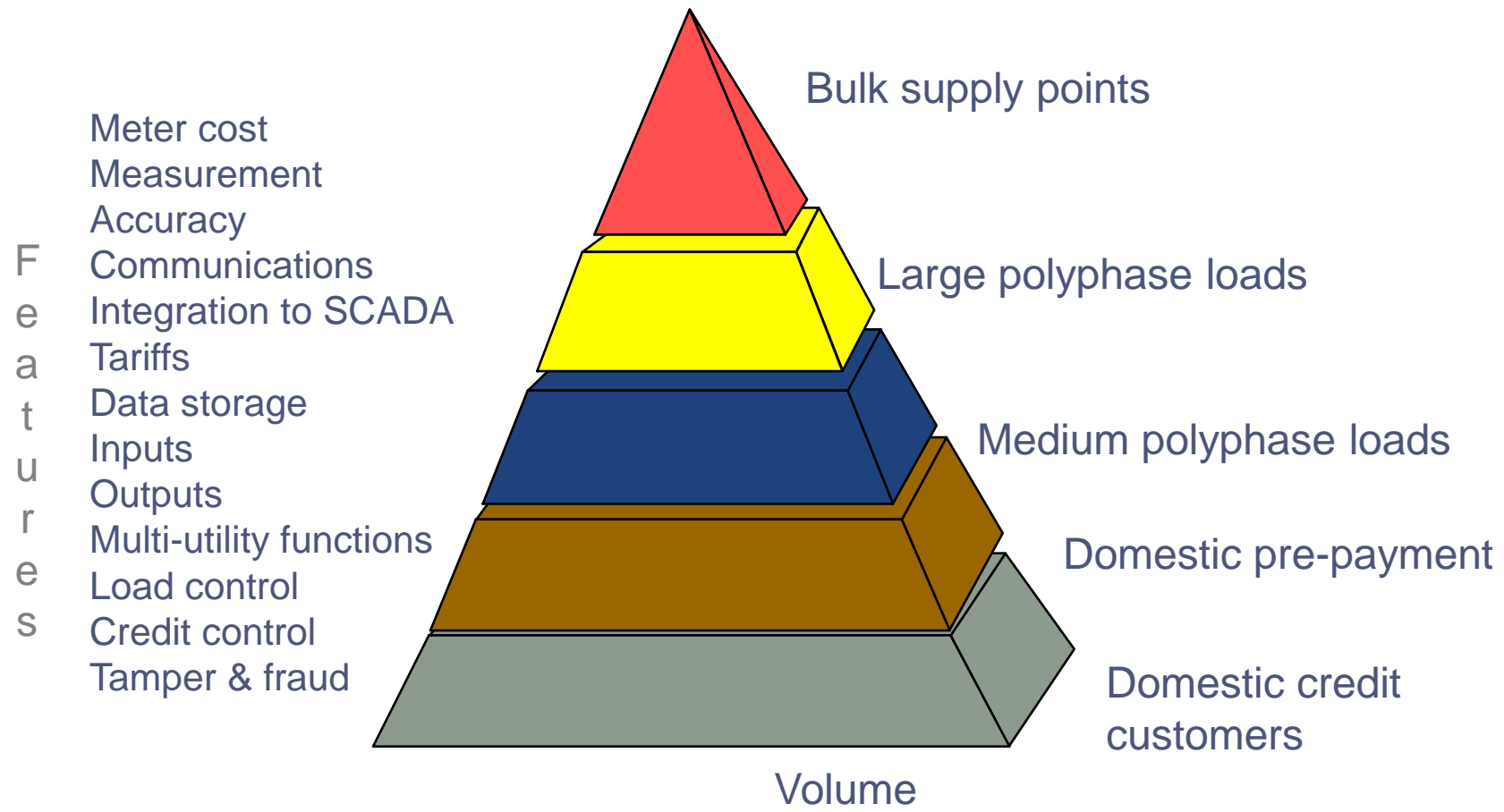


Computer system and software



[back](#)

Electronic products: everything you need!



[Back](#)

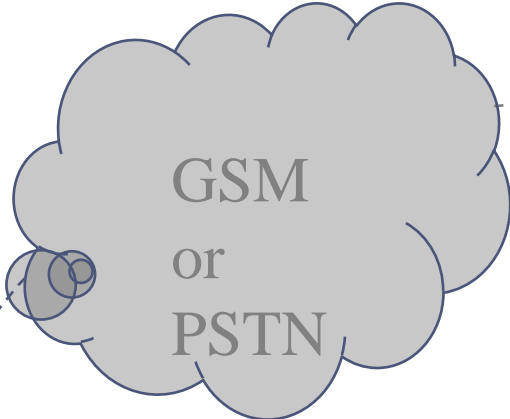
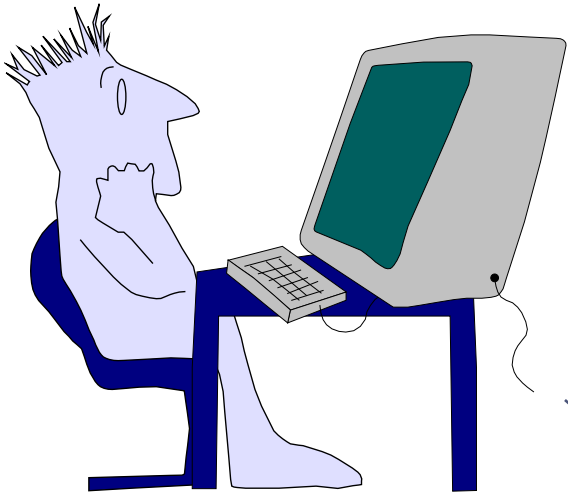
Communication options

- **Local communication using Professional Hand Held.**



[Back](#)

Communication options: Remote Communication



Modem

[Back](#)