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Regional Energy Security, Efficiency and Trade (RESET)

Workshop on Market Models and Information Systems

AMR implementation issues

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AMR: Key to Successful Implementation

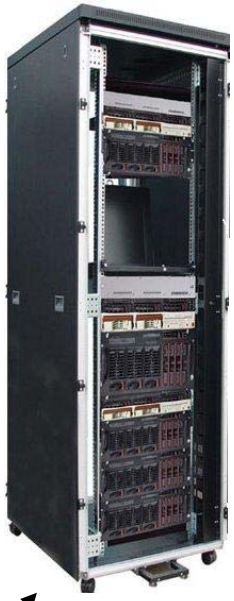
Success of implementation of an AMR - Automated Meter Reading systems – depend heavily on the ability of a central metering service to quickly obtain metering data from all meters and link these data to other software and data processing systems established in the market. For this purpose:

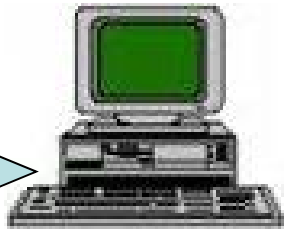
1. The automatic data acquisition of an AMR system should comprise the meters responsible for at leas 50 % of electric power traded in the market
2. An AMR system should be capable of including data from the meters not capable of communicating data remotely by allowing for a manual entry procedure and / or a procedure for transferring meter data files with predetermined format.
3. The system needs to be open for communicating with other types of meters and other AMR system's software
3. On top of that, there should be a market's proprietary software which has an access to the metering data maintained by a certified AMR software and, based on these data, makes all technical and financial calculations in accordance with market arrangements and produce all documents as prescribed by the market rules.

AMR System: Link to Market Software

Master AMR data base

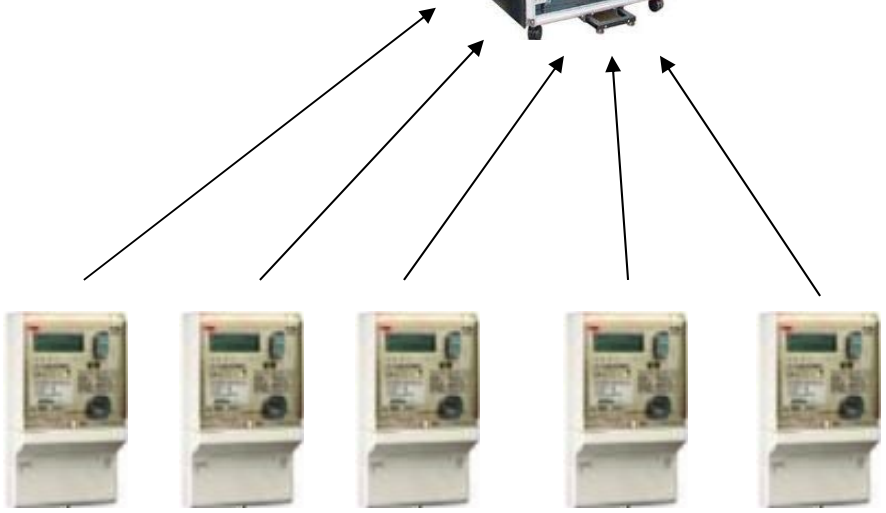
Standardized and Certified AMR Software





Power Market Software

Electricity Pricing, Development of Reports, Financial Settlements, Payments



In absence of this link the metering system remains effectively a technical metering system, not a billing (commercial) metering system

Is a Full Unification Needed?

Unification simplifies significantly implementation of big systems. Use of only one type meters or at least meters that are compatible with one AMR software would decrease the training time, improves interchangeability of maintenance personnel;

With the number of meters less than 3000 all metering data can be collected by and stored in one server by a regular and direct polling of all meted from one center.

HOWEVER:

- Such unified systems are hard to be upgraded in the future
- Within meter's average inter-testing period of 8 years, a next-generation communication, computer and server equipment comes to the market;
- During the meter service life of 20 – 30 years, a system that comprises meters of only one type is getting completely obsolete

Implementation Examples

- Each of AMR system implemented at the national level in relatively small power systems of Georgia and Armenia with only one type of meters and one type of AMR software throughout the whole country was an undoubted successes for its time.
- Currently these systems experience difficulties in adopting contemporary meters with improved functionality into their system.

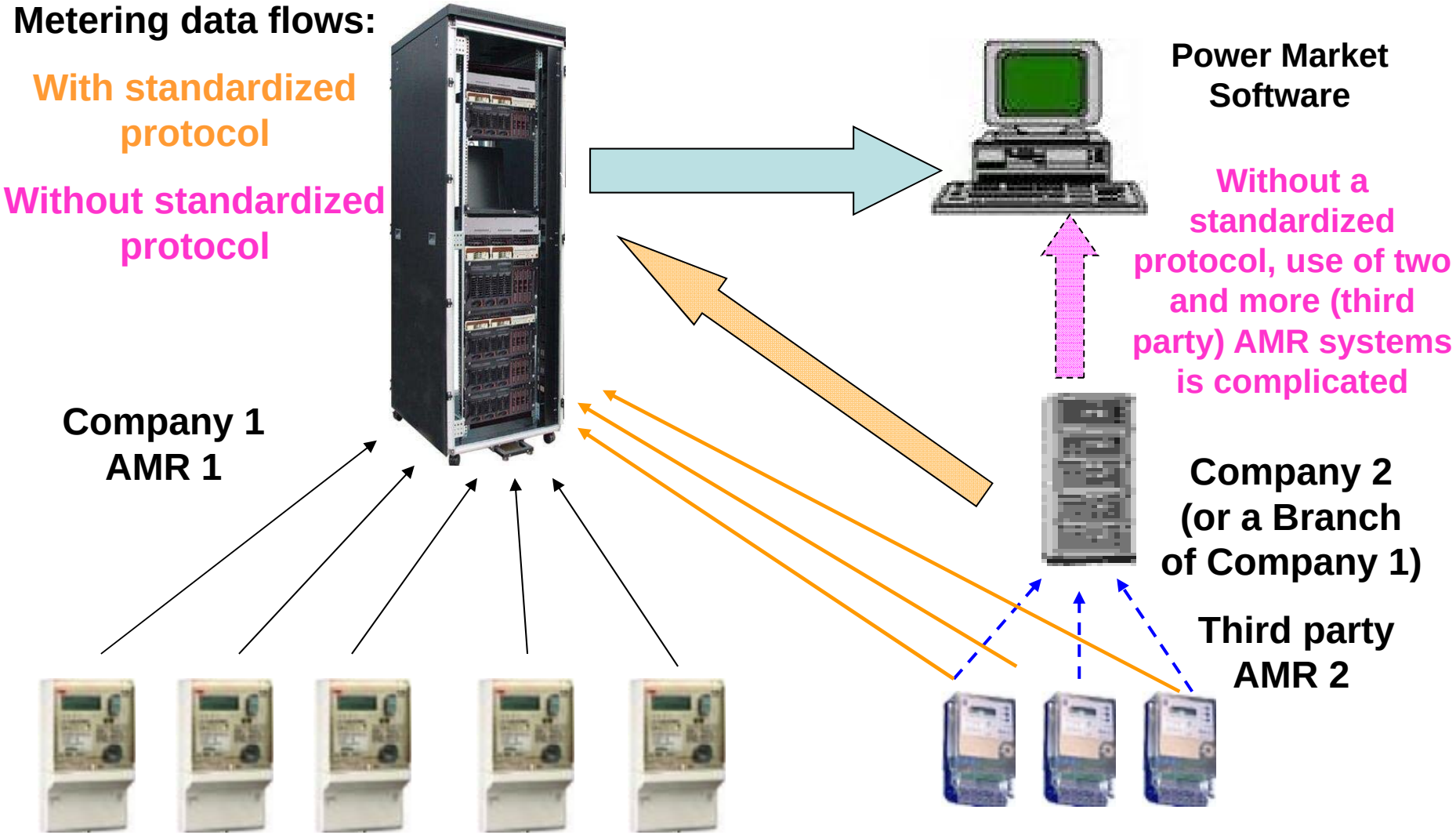
Protocol Unification

- In large power systems or energy amalgamations where more than 5 thousand meters is needed, it is not feasible to employ meters or AMR software of only one type. This is why not unification of hardware or software, but unification of interfaces and protocols is needed through which the metering data would be transferred to the central metering database.
- The same requirement ensues from the need to have a system that is open to modernization and capable of being integrated into modern systems of power system supervision and management - SCADA, EMS, etc.

Implementation Examples

- Sooner or later, all large power systems come to a need for the communication protocol unification / standardization at the high level of metering data acquisition.
- For example:
  - a high level protocol chosen in Kazakhstan is the FTP protocol
  - In Ukraine – an attempt to adopt a unique proprietary protocol designed exclusively for metering data acquisition systems (not yet implemented)
- Meanwhile, during the fast introduction of AMR systems in former Soviet countries (starting the end of 1990s) several communication standards have appeared defining the rules of communication inside and between power utilities and control centers, in particular, IEC 60870-6 (ICCP) and IEC 60870-5 (DNP3). They are actively introduced in modern SCADA systems but, for some reasons are not employed in AMR systems.

Combination of AMR Systems of Different Makers



Use of RTUs

- RTU - Remote Terminal Unit - a local intermediary controller with functions of collecting data from local meters, sorting them by metering intervals, long-term storage of the interval data and transmitting them to an upper level controller or the Master Metering Database. An important feature of the RTUs used in metering systems is the capability to connect meters equipped only with a pulse output, which enables integration of old meters into modern AMR systems.
- A personal computer equipped with communication interfaces can also be used as an RTU
- If a substation or other energy entity uses only modern multifunctional electronic meters, use of RTUs is redundant and not recommended

Use of RTUs (2)

Master AMR database

RTU at an object

PC as an RTU

The configuration is recommended only if simple meters with pulse output are used at an objects
OR
if the RTU is used by both AMR and SCADA systems

Static multi-functional meters

Meters with pulse output

Use of RTUs (3)

Master AMR database

RTU at an object

PC as an RTU

If only modern multifunctional meters are used at an object and there is no SCADA elements, use of RTUs is not recommended

Static multi-functional meters

Meters with pulse output

Use of Nodal / Regional Centers

- If local AMR systems with their own local metering database servers are installed at major market's participants or in large substations, then such servers can be used as "RTUs" for market's master AMR station.
- Even with such a hierarchical topology of an AMR system, the system should be capable of providing direct access from the central / master AMR station to each individual meter.
- Electricity meters are integral parts of the market metering database. And this is the most reliable and informative element of this database which provides high level protection from unauthorized access.

Direct remote access to meters from the master AMR station is an important feature of the automated metering system.

Hierarchical Structure of AMR System

Master AMR database

Regular data transmission to Master AMR system

AMR Database of market participant, major power plant or substation

Direct remote access to meters is an important requirement for the AMR architecture

The information stored in the local / regional database is not as full as the source information stored in meters

Regular meter data acquisition through a local network

Static multi-functional meters

Building a National AMR System

- When implementing AMR services at the high level – national metering service operator, settlement center etc., possibility to poll each meter directly, down to the lowest level, is of paramount importance, although the regular procedure stipulates collection of data from regional / nodal lower-level data acquisition centers (as a rule, in already processed form) not directly from the low level meters.
- This possibility is supported:
  - for small power systems – by limited types of meters and employment of one type of software which can poll types of the meters directly, either remotely or through a wired connection
  - For big power systems with a wide range of meters of different type and different off-the shelf AMR software solutions at the utility / market participant level – by a query initiated by the master AMR database to a lower level database to the meter through a **UNIVERSAL PROTOCOL**.

AMR: Communication with Objects

- In formulating technical references for AMR systems there is no need to impose strict requirements to speed of communication channels and their availability levels so that possibility remains to use any available channels at hand: corporate communication system, PSTN, Internet, GSM, GPRS etc.
- Availability (readiness index) of 75% is more than enough for metering data acquisition
- Backup ways of data transfer: optical port readout, sending by e-mail, physical transfer by a flash drive etc.

AMR system is a metering system – not a communication network!

Time Synchronization Requirements

- There is no need in stringent requirements to the meter and AMR software time synchronization both among themselves and with the Universal Time Coordinated (Official national time)
- Synchronization accuracy of +/- 10 s is quite enough
- Clock accuracy of +/- 5 s per day is quite enough
- In practice, these requirements are met with a wide margin
- One should remember that a 0.2s accuracy meter does not have to produce an accuracy of 0,2% at any time interval. To reach this accuracy, at least 5000 measurement pulses are needed.
- With a full load of 5A and 100 V, 866 W will go through a meter, which translates into 8660 pulses in an hourly interval (Кн = 20 000 pulses/ kWh). During half an hour, the time accuracy should be no greater than 10% of the main error, that is less than 0.36 c, or 17.28 s per day.
- With shorter intervals the number of pulses will be less than 5000, and requirement to improve the clock accuracy does not make sense
- Synchronization from one server which in turn is synchronized via NTP protocol is enough for an AMR of any scale
- **AMR is a metering system – not a precise time dissemination system!**

AMR: Metrological Requirements

It is not recommended that a whole AMR system be subject to metrological certification and testing.

Metrological requirements should be limited to metering installations, that is the instrument transformers and the meter itself.

Registration of an AMR system in a state register of measuring means is an arguable solution.

- This solution results in obligatory regular metrological testing and hence turns an AMR into a closed system.
- At the same time, there is - as a rule – a need to continually transfer the AMR database to a market proprietary software which is not subject to metrological control.

AMR: Data Protection Requirements

Requirement to protect data from unauthorized access does net necessarily mean that the whole system has to be closed and isolated from other systems. It is a very important issue especially when introduction of a AMR system is linked to the expectations of reduction of “commercial losses”.

In determining necessary requirements for metering data security or requiring, out of security consideration, full isolation of a metering system from other market information systems, one should remember that:

- No metrologically approved or certified AMR software will permit a market settlements department to use it for issuing invoices. There should be other dedicated software based on procedures prescribed by Civil Code, Tax Code, accounting rules etc..
- In litigations or dispute resolutions over metering data, the data stored in the meters should be used as a reference because meter is a measuring device which is metrologically certified and approved and protected from tampering much better than computer server with an AMR software.

Desire to eradicate tampering with metering data should not lead up to an AMR system to be isolated and closed. Quite the opposite, an all-embracing and transparent AMR system capable of quick data verification against SCADA data or by checking nodal balances, will result in elimination of tampering which as a rule, take place at the level of metering installation.

AMR: expectations and reality

Advantages

Implementation of automated meter reading systems based on intelligent multifunctional meters with remote reading of commercial / technical metering data:

- Renders metering at customer's, generator's sites and in large power utilities more complete, transparent and easier for thorough monitoring
- Makes tampering with metering installations significantly harder
- Enables measurements of power quality parameters
- Creates preconditions for switching to interval metering which is important requirement of modern power markets pricing (hourly prices, time-of-use tariffs, etc.)

AMR: expectations and reality Cont'd

Advantages

- Cuts labor cost for taking and processing the meter readings
- Creates a reference base for systematic analysis of metering, timely revealing of metering installations' errors and gradual improving of accuracy of commercial metering
- Enables customers to control their electricity consumption and introduce energy saving and energy efficiency programs
- Market operators / commercial dispatchers can use the interval metering data for a more precise performance of declared bilateral agreements and for application of hourly price bids/offers in sophisticated energy or balancing markets

AMR: expectations and reality Cont'd

However:

- Some market participants and parties to bilateral agreements express their concern about loss of confidentiality of commercially sensitive information
- Foe residential customers – breach of privacy: information on the in-house activities become accessible by outside persons (time when you use lights and powerful home appliances, periods of absence from home etc,)
- Decreased reliability because of use of sophisticated devices and dependence on communication channels. Particularly in case of prepayment meters
- Expectations for the raise in revenues due to improved metering accuracy are not always legitimate

AMR System: New Quality

The main objective of deploying an AMR system is to create prerequisites for clear understanding of the structure of generation, transmission, distribution and consumption of electric power and, consequently, for optimization of all levels of power system's technological chain and further to introduction of modern sophisticated models of pricing for energy resources and organizing efficient electricity markets

In relationship between distribution companies and customers: compulsory, controllable and credible metering. Increased confidence in metering procedures and growth in mutual confidence

For customer's level – significant improvement in accuracy of hourly consumption, possibility to optimize internal technological processes and reduce the cost of purchased power, Prerequisite for participation in modern wholesale and retail electricity markets.

AMR: Priority of Tasks

- This is metering systematization, improved protection of meters against tampering and possibility to create efficient electricity markets and further introduction of modern pricing methodologies that will justify high costs of AMR system implementation.

- Improvement of metrological accuracy of commercial metering should not be a first priority task but needs to be contemplated as one of the long-term goals of metering modernization. For this reason, from the very beginning a utility should seek for replacing measuring devices and instrument transformers with devices of higher accuracy classes

AMR: gradual improvement of metering accuracy

- Use of multifunctional static meters with accuracy class of 0.2s and 0.5s will not necessarily result in additional revenue due to the electricity volumes that earlier were attributed to losses or unaccounted for; относившейся к потерям.
- For load range of 0,01 In – 0,05 In, where meters of 0,2s or 0,5s accuracy classes have significant advantage over other meters, the accuracy of ordinary instrument transformers is not normalized.
- Precise meters combined with interval metering allow for comprehensive analytical work that encompass entire utility and makes it possible to reveal and eliminate errors and other problems with metering installations.
- Replacement of meters, especially if the replacement is done only on selected feeders, without possibility to check power balances using data from similar meters will not bring desirable results.

AMR and SCADA Systems

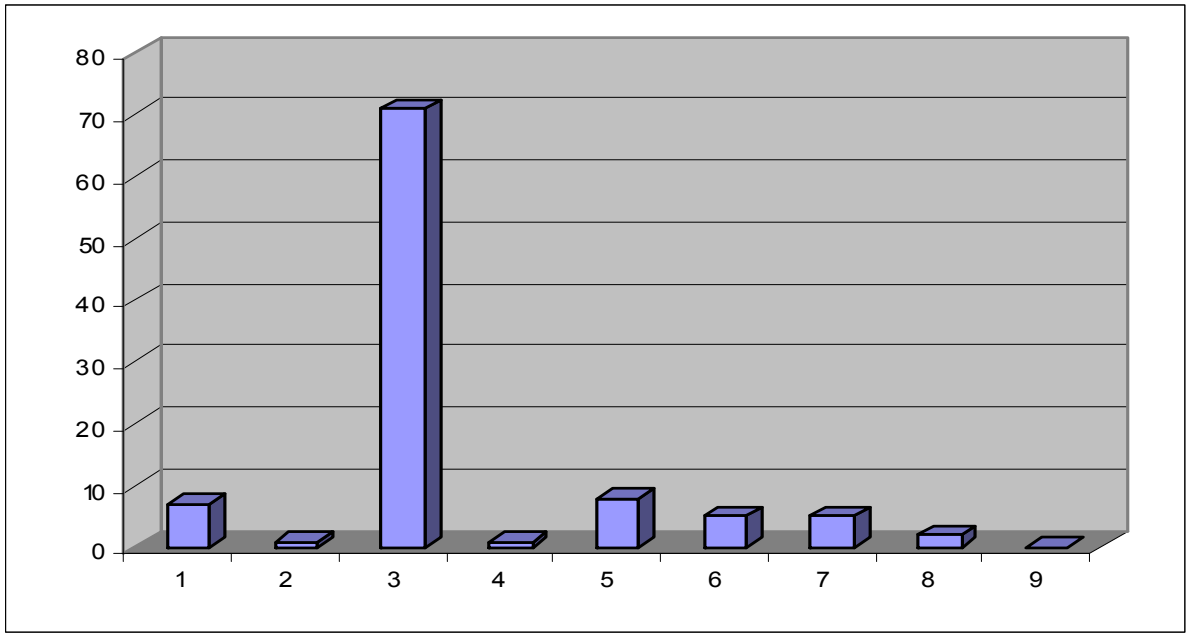
Modern electricity meters with their rich variety of features open the new fundamental opportunity of using them as transducers for SCADA systems.

Such an application of electricity meters may be recommended, however, it should be noted that:

- Measurement of grid parameters is supplemented in watt-hour meters just for commercial purposes, that is to measure quality of the power supply as a part of contractual obligation of a supplier.
- AMR and SCADA systems may exchange data at database server's level for additional verification or for recovery of essential information in case of major loss of metering data due to meter's failure
- Use of one meter as a common source of data for AMR and SCADA systems would compromise reliability of both systems

AMR: major sources of errors

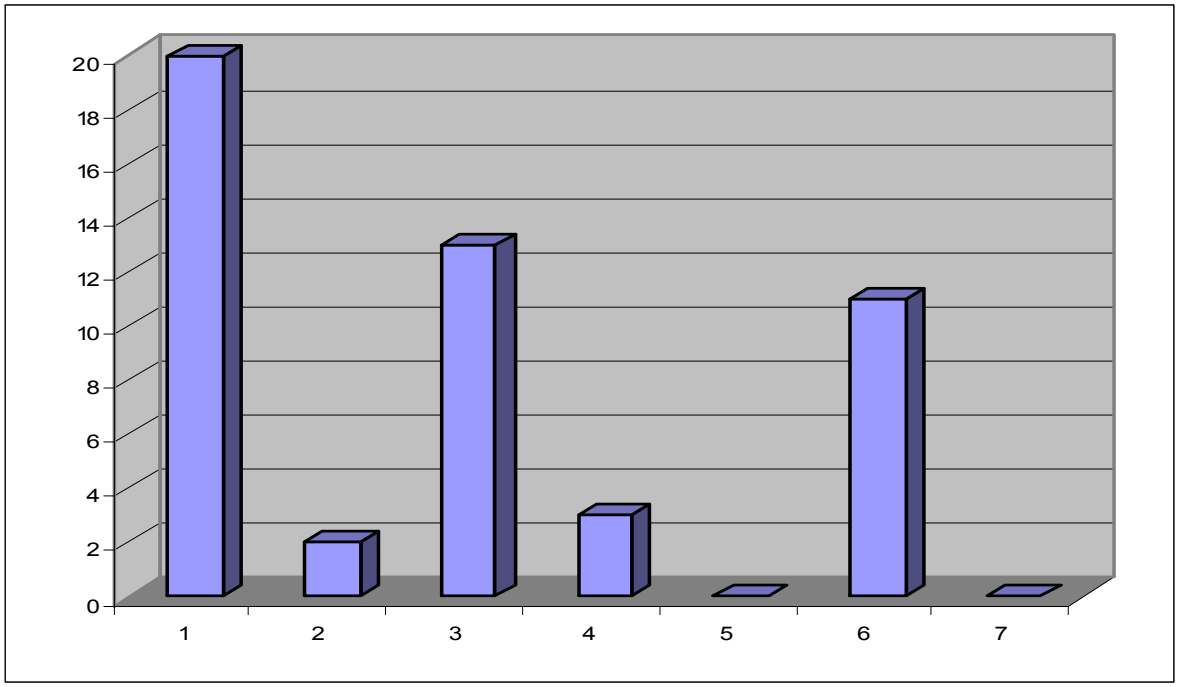
Contribution of different factor in overall metering error of measurement channel



1. Amplitude error of CT
2. Amplitude error of VT
3. Wiring error
4. Voltage loss error
5. Basic error of electricity meter
6. Auxiliary error due to temperature
7. Auxiliary error due to magnetic field 50 Hz
8. Other auxiliary errors
9. RTU error (A/D)

Sources of errors: instrument transformers

Cases of breaches of operational conditions in AMR systems



1. VT is overloaded
2. VT is under loaded
3. CT is overloaded
4. CT is under loaded
5. VT losses are greater than permissible
6. Temperature of meters is outside the range
7. Magnetic field is greater than permissible

THANK YOU

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