INTRODUCTION

The paper presents how the consumption areas that should be disconnected because of non-payment of the consumed energy, are limited and the reduction of energy losses caused by electric energy theft.

On Galati Distribution Utility (SDFEE Galati) order, the Design and Consulting Workshop within Galati Agency have issued a project on “Improvement of the technical power supply conditions of consumers in Toflea village, Galati county”, that developed the h.v. energy distribution concept that uses low power transformers. Toflea village is a village belonging to Brahasesti commune, located in north-west of Galati county, at 115 km from Galati town and 35 km from Tecuci town where the Customer Center is also located.

On the 20 kV derivation that supplies the village, there is a measurement bay for recording the energy supplied to this village. In table 1 following are presented: circulated energy, billed energy and the unbilled energy for a 5 year period. The diagrams show that the unbilled energy is very large (for the 5 years, it represents 84% of the circulated energy). Obviously this is eventually included in the own technologic consumption of SDFEE Galati.

TABLE 1 - Energetic situation in Toflea locality on the last 5 year

<table>
<thead>
<tr>
<th>YEAR</th>
<th>Circulated energy (MWh)</th>
<th>Billed energy (MWh)</th>
<th>Unbilled energy (MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>3498</td>
<td>935,599</td>
<td>2563,401</td>
</tr>
<tr>
<td>1999</td>
<td>3378</td>
<td>847,952</td>
<td>2531,048</td>
</tr>
<tr>
<td>2000</td>
<td>4211</td>
<td>683,917</td>
<td>3527,083</td>
</tr>
<tr>
<td>2001</td>
<td>5268</td>
<td>386,773</td>
<td>4881,227</td>
</tr>
</tbody>
</table>

As it can be seen in this diagram, the unbilled energy increases except the last year when a certain decrease can be ascertained due to the checking actions for detection of current theft and debt collection. The measures taken for reduction of these losses, respectively the periodic checking for detection of thefts, disconnection’s because of unpaid consumed energy, secure derivations (with measurement and protection module and coaxial conductor) have had short term effect. After being disconnected because of unpaid of the consumed energy, the consumers have connected themselves to the low voltage network so that certain phases were overloaded and the insulation of the twisted conductor melted. Another negative implication was the destruction of distribution boxes and the burning of columns at the transformer points. In order to eliminate the thefts in this village, SDFEE Galati proposed following to be studied:

• Reduction of the consumption areas at an average number of 20 consumers per transformer point in order to reduce the number of disconnected consumers for consumed energy unpaid;
• Reduction of the low voltage line;
• Energy consumption metering in the distribution box of the transformer point and use of a remote meter reading system;
• Reduction of the supply interruption number and limitation of the area affected by faults in Toflea area caused by unauthorized personnel.

CURRENT SITUATION

Toflea village is connected to the Tecuci Distribution Center, through the 20 kV Toflea derivation supplied from the 20 kV Tecuci-Ciorasti line whose source is 110/20 kV Tecuci Balcescu substation. The supply path has a length of 28 km to the supply substation. The power distribution is performed by low voltage networks, with twisted conductors, connected to six overhead transformer points, with following characteristics:
In the village there are also another 6 overhead transformer points that supply individual consumers. These points are not the property of SDFEE Galati. The transformer points owned by SDFEE Galati and the low voltage networks have about 70% wear because of the followings:

- high energy consumption for each household;
- unauthorized personnel access, i.e. the energy theft by some consumers.

**CHosen Solution**

The chosen solution is based on the h.v distribution concept and involves the following works:

- Setting-up 49 new overhead transformer points with following equipment: 30 points with 20/0.4 kV three-phased transformers, \( S_n = 25 \) kVA; 13 points with 20/0.4 kV three-phased transformers, \( S_n = 40 \) kVA; 2 points with 20/0.4 kV three-phased transformers, \( S_n = 16 \) kVA; 1 point with 20/0.231 kV two-phased transformer, \( S_n = 10 \) kVA; 2 point with 20/0.231 kV two-phased transformer, \( S_n = 16 \) kVA and 1 point with 20/0.231 kV two-phased transformer, \( S_n = 25 \) kVA.

The transformer points were located on a SC 15015 pole where following equipment will be mounted: switch in vertical position, safety and surge-arrested common frame and the distribution box that will be installed on a metallic frame between the point pole and a SC 10005 pole (fig. 1).

**DISTRIBUTION AUTOMATION WORKS**

Because the Toflea connection is far from Tecuci substation and having in view the big number of connected points specified in the project, a recloser on pole 7 of Toflea derivation was proposed.

**REMOTE READING OF METERS**

Remote reading of meters located in the distribution box (fig.2) of the transformer point mainly involves Enerlux-M electronic single-phased meters for 1130 measurement points, located in the distribution boxes mounted on the designed transformer points. The distribution box has two separate compartments: energy measurement compartment where the meters are located and the general supply-distribution-protection compartment; each compartment has a door and the door of the meter compartment has windows for meter reading.
The scheme of remote reading of meters is found in fig. 3.

![Scheme of remote reading meters](image)

fig. 3 The scheme of remote reading meters

The system mainly performs the following functions:
- remote reading of the single-phased electronic meters mounted in the transformer boxes;
- telephonic channel data transmission to Control Center (CRC Tecuci);
- database setting-up and storage for the data collected at Control Center (CRC Tecuci).

In the transformer points that have MUX8C multiplexer, the number of remote reader meters can be further increased up to maximum 30 Enerlux-M meters/substation depending on distances and configuration, without the need of other additional equipment beside the electronic meters and connections to the multiplexer. The maximum distance between the multiplexer and the most distant meter (or another multiplexer) will be about 500 m measured in cable length.

The data transfer between the measurement points and collection points is made according to IEC 1107, the connection itself being an electric interface of current loop type.

The system software will operate under Windows XP/2000 and the databases will be created in Microsoft Access.

LOW VOLTAGE SUPPLY OF THE CONSUMERS

The low voltage supply of the consumers will be performed with derivation conductors sized according to the “Design guide for electric derivations” and PE 155 “Regulations for the design and set-up of electric derivations”.

The possibility of low voltage supply was analyzed and following were proposed:
- the new derivations for buildings close to the transformer points will be performed with twisted conductors mounted on 1 – 3 poles. For the support of the derivation conductors, the existent and designed medium voltage poles, the existent low voltage poles and the existent derivation poles will be used.
- for longer derivations, twisted conductors with carrier earthing will be used. This solution will be used in certain situations where the field conditions didn’t allow the design and performance of a medium voltage connection and a transformer point.

CALCULATIONS

Using the DINIS program, following were calculated:
- active power losses on 20 kV Tecuci-Ciorasti line, on the transformers connected to this line and the total losses. Using these results, the circulated energy and active energy losses on the 20 kV line and 20/0.4 kV transformers were calculated for the existent and designed situations.
- the voltage drops in the 20 kV network for the existent and designed situations. At the end of the analyses networks, these drops are the following:
  - existent situation – 26.1%;
  - designed situation – 9.7%

In the existent situation, the voltage drops exceed the allowed limits ($\Delta U_{\text{max,adm}} = 10\%$ according to STAS 930/1989).

Thus the designed versions were calculated for another configuration of the 20 kV diagram, respectively the opening of the 400 switch on the Tecuci-Ciorasti line and the closing of the loop switch 0, located between this line and Tecuci-Ghidigeni line.

For the same reason the output substation cable with 95 mm$^2$ cross-section will be replaced by a new cable with 150 mm$^2$ cross-section cable and the 35 mm$^2$ existent conductor shall be replaced by 50 mm$^2$ conductor on Brahasesti derivation.

In this configuration, the voltage drops are within permissible limits.

<table>
<thead>
<tr>
<th>Load flow analysis results</th>
<th>Designed situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supplied kW</td>
<td>4167</td>
</tr>
<tr>
<td>Total point load kW</td>
<td>3427</td>
</tr>
<tr>
<td>Total distributed load kW</td>
<td>739.5</td>
</tr>
<tr>
<td>Total loss kW</td>
<td>622</td>
</tr>
<tr>
<td>TF shunt loss kW</td>
<td>55.5</td>
</tr>
<tr>
<td>TF shunt kvar</td>
<td>715.7</td>
</tr>
<tr>
<td>TF series loss kW</td>
<td>62.1</td>
</tr>
</tbody>
</table>

ECONOMIC EFFICIENCY

In order to find out the efficiency of the proposed investment and the capacity of covering the expenses and obtain profit, the main economic efficiency indicators were analysed: the actualized net income, internal rate of return, actualized recovery time, breakeven.

The total incomes were analyses, including: incomes from energy sales, incomes from theft prevention and incomes...
resulted from reduction of the own technologic consumption. The total expenses were also analyses including: investment costs and maintenance and operation costs. Following results of the economic efficiency indicators were obtained:

- Actualized net income: 1237293 euro;
- Internal rate of return: 25.89%;
- Actualized recovery time: 7 years;
- Total actualized income/expense ratio: 1.29;
- Breakeven: 77.29%

These results show that the investment is efficient so that it was promoted by SDFEE Galați, this project being under performance at the time being.

CONCLUSIONS

This works which were present in this paper represents a challenge for Galati Distribution Utility and for Galati Agency and at this moment gave in good results. The principal benefit is caused by the reduction of loose registered every year because of electric energy theft. The remote reading system provides the required information in due time so that the expenses are decreased for efficient power management. The system monitors the performance indicators providing information concerning the power consumption based on the data supplied by the meters located in the measurement points.