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The Advantages of the Applicability of New Generation Sectionalisers and Reclosers Over the Pole

Abstract. *These new generation devices which are being tried for the first time in our country are low cost, can be used instead of output cells of transformer centers which are in medium-voltage lines experiencing problems of expropriation, offer the maximum level of security, don' t require maintenance for 20 years and offer an easy opportunity to intervene. In addition, protecting the working efficiency of these new products' electricity transmission lines and distribution systems are evaluated in this study.*

Streszczenie. *W artykule opisano zastosowanie sekcjonalizerów i reklozerów w sieci elektroenergetycznej, jako urządzeń o stosunkowo niskich kosztach utrzymania i dobrych parametrach ochrony linii. Omówiono warunki działania urządzenia w praktyczny zastosowaniu. (**Zalety stosowania sekcjonalizerów i reklozerów nowej generacji na slupach elektroenergetycznych**).*

Keywords: sectionalizer, recloser, feeder automation.
Słowa kluczowe: sekcjonalizer, rekloser, automatyka zasilania.

Introduction

In this study, it is aimed that the electric power systems operate in a secure and desired way. Today, electricity has become one of humanity's most vital needs. With the development of technology, the need for electricity increases by 4% -8% every year. Meeting the increasing electricity needs and the inclusion of the new power generation centres and the energy transmission lines in the system has become inevitable [1, 2, 3, 4]. The functionality of new generation sectionalisers (NGS) and reclosers (NGR) over the pole which are low cost, can be used instead of output cells of transformer centers, offer the maximum level of security, don' t require maintenance for 20 years and offer an easy opportunity to intervene [5, 6, 7]. Performances of the NGSs and NGRs providing protection of electrical distribution systems and separation of damaged sections of lines are also evaluated in pilot areas. In addition, it is indented to contribute to introduce these devices to our country's entrepreneurs and industrialists.

Today, the protection of power transmission and distribution lines, separation of damaged sections of lines as soon as possible and minimizing the power outages has been made compulsory with the regulations by the public institutions. Accordingly, in the regulations published by the Electricity Market Regulatory Authority (EPDK) for the security of the supply, new mandatory sanctions have been imposed for the companies that have undertaken the distribution of electrical energy. General overhead power transmission and distribution line faults stem from the natural conditions such as rain, snow, storm, birds, and tree branches. In general, the faults at any point in the network of distribution lines, which are designed according to the fringed grid have negative effects on all consumers. To that end, for the fault detection and for the separation of the damaged sections of lines from the system as soon as possible and the minimising the number of the non-energy regions, new generation sectionalisers (NGS) and reclosers (NGR) have been developed.

New Generation Sectionalisers and Reclosers

Otomatik See the general figures of the new generation sectionalisers (NGS) and reclosers (NGR) Figure 1.

New generation sectionaliser (NGS) is a sort of mechanical circuit breaker which has a digital-microprocessor-based structure and identified with the related voltage level without human intervention, which can break short-circuit current, and which is capable of re-closing automatically at the end of the time set. The new generation sectionaliser (NGS) is a switching element which has a digital-microprocessor-based structure, which is capable of carrying, breaking and closing rated normal current and carrying the short-circuit currents for a set of time and closing the current upon the short circuit, providing a minimum isolation level for the isolators in the open position [8].

a) Recloser wiew b) Sectionaliser wiew

Fig 1. The general figures of the new generation sectionalisers and reclosers

The functions to be realised by the NGS that are used in the study conducted herein are as follows:

- Breaking and re-closing in the phase-earth faults detected,
- Detection of errors and the observation of the status of the distribution lines,
- The measurement of the values such as current and voltage in the line
- Working according to the different time-current curves
- Closer and remote control options,
- Communication with the control centre and DNP 3.0 protocol,
- Self-diagnostics (measurement of power, temperature, memory etc.)
- Communication with the terminals connected
- Automatic control of the installation of the device,
- Analysis of Fault current curve according to the phases,
- Comparison of the measured values with the previously memorized information,
- Transfer of the measured values to the computer and their analysis.

The functions to be realised by the NGR that are used in the study conducted herein are as follows:

- Phase fault detection
- Earth-fault detection
- Sensitive earth-fault detection
- Line on / phase mismatch detection

The body of NGS and NGR is made of stainless steel. In the body of NGS, there are reclosers, drive mechanism,

current transformers and voltage sensors. The body is grounded, the required structure for the installation of the surge arresters to be used to both of the directions of the line has been located on the main body, and by this way the system was enabled to be in a compact structure. The mechanism has a structure within the body, and it is fully protected. The structure carrying the body has been designed in a way to be easily installed to any pole. The mechanism of the NGS can be opened manually or electrically, but it can only be turned off electrically. Open or close status of the NGS is visible from below. In manual opening, it is designed to use cue. The bodies of the NGS and NGR are fully closed, ant they are filled with the gas of SF_6 via sealed pressure system. For about 20 years, without any additional gas, it can disconnect all the currents at the relevant level of voltage. Due to the pressure switch of the gas of SF_6 installed on the body enables the mechanism to be locked and does not allow the recloser to close in the case that the gas falls below the level of 0,5 bar. The stainless steel has a structure of releasing the excessive pressure that may arise pursuant to the installed pressure relief system. In the event that the gas pressure exceeds 2.5 bar, this cover shall be opened and relieve the over-pressure.

The body of the NGR comprises the sectionalisers current cut-off system, current transformer and the voltage sensors. The body is grounded; the required structure for the montage of the surge arresters to be used for both of the directions of the line has been located on the main body. The mechanism of NGR is appropriate for the manual or electrical operation. The mechanism has a structure within the body, and it is fully protected. Opened or closed status of the NGS is given below. Technical features of the NGS and NGR are offered in Table 1.

Table 1. Technical features of the NGS and NGR

Technical features of the NGS and NGR	NGS	NGR
Rated Voltage	38 KV	36 KV
Nominal Rated Current	630 A	630 A
Rated frequency	50 Hz	50 Hz
Short-time strength	16 kA	12,5 kA
Current Short Circuit Strength Time	1 second	1 second
Peak / Internal arc strength current	40 kA	40 kA
Closing / Opening Time	0,1/005 s	0,1/005 s
Rated SF_6 pressure	1 bar	1,6 bar
Height	1000 m	2000 m
Ambient Temperature	-30 +50°C	-25 – +40 °C
Humidity	% 0 – 100	95%
Lightning strength rated voltage (peak)		
- Intra-Phase- earth	170 KV	170 KV
- Cutting the range	195 KV	195 KV
1 min. power frequency strength voltage		
- Intra-Phase- earth	70KV	70KV
- Cutting the range	80 KV	80 KV
Mechanical operation	10.000 times	10.000 times

NGR the equipments of NGS and NGR can be grouped in general as follows: NGS main body (recloser and its mechanism, insulators, current transformers / sensors, bars appropriate for the capacitive voltage transformers), NGR main body (gas-insulated isolator and its mechanism, insulators, current transformers / sensors, bars appropriate for the capacitive voltage transformers), conductivity of various connection cables and control & communications panel (battery-rectifier group, relay, LCD display, the position selector). The battery-rectifier group in the control and communications panel is comprised of semi-conductor “rectifier” in the type of current limiting and automatic regulation, and the "accumulator" that can be charged by the rectifier and continuously connected to the rectifier. Rectifier has been produced in a structure of protected against the transient pulse voltages of internal and external sources, short-circuit, overload and reverse battery connection. Accumulator has a capacity of providing the means for all the electrical operations related with the NGS for 48 hours and for the realization of at least 50 on-off cycle.

NGS has been designed in compliance with the rapid re-closure system in the airless vacuum environment, three-pole two-position (open-closed), switching (breaking-closing). SF_6 has been used in the insulation of the switching elements belonging to the recloser (vacuum tubes), bars used in their connection, conductors and the similar parts under the voltage. All active parts under voltage are made of stainless steel and they are in a hermetically sealed metal casing.

It is made up of a few mechanic parts and capable of rapid opening and closing. The new generation operating mechanism of the magnetic drive technology, offers the opportunity to use the device without the necessity of lifetime care. It is rust and corrosion resistant. The new generation reclosers (NGS) have the property of mechanical and electrical opening. Sample views of the NGS mechanism are shown in Figure 3.

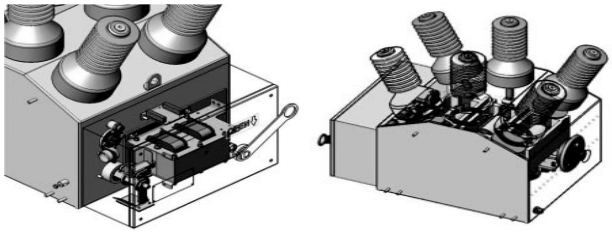

Fig. 3. Sample views of the mechanism of recloser

NGR’nın The installed figure of the NGS on the line at Gölbaşı district of Ankara, Tuluntaş/ Oğulbey neighbourhood is offered in the Figure 4.

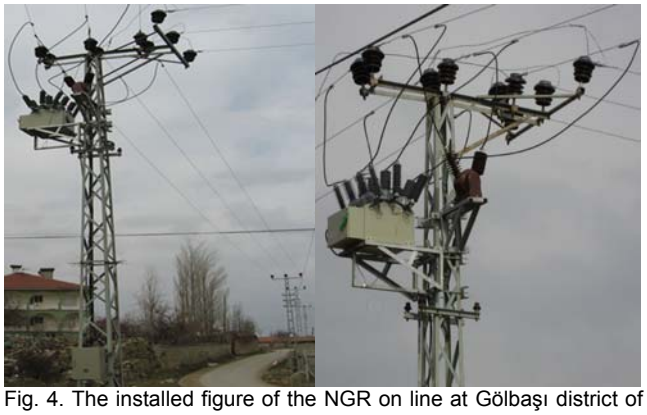

Fig. 4. The installed figure of the NGR on line at Gölbaşı district of Ankara, Tuluntaş/Oğulbey neighbourhood.

NGS control mechanism is located at a section that integrates with the body of NGS. System that is made up of a few mechanic parts is capable of rapid opening and closing. The mechanism conducts the on/off operations automatically. The electric motor voltage is 24 V DC and has the strength of opening and closing the system for dozens of times one after another. The electric motor has the voltage and has the strength of opening and closing the system for dozens of times one after another. The mechanism has passed the test of opening and closing

successfully for 5000 times. NGS has been subject to the ice test, and it has been observed that the device worked without any problems in a condition of covered with ice above 10 mm thick. Thanks to the electrical and mechanical indicators of the mechanism, the position of the isolator can be observed both closely and from a distance away. The opening and closing operations can be performed easily with the remote control [6]. The image of NGS is given at Figure 5 before it is installed.

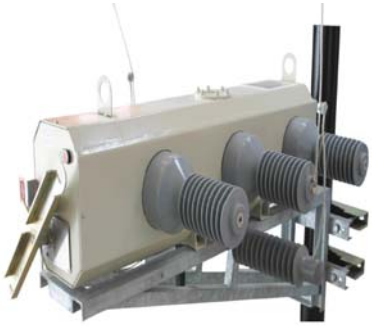

Fig. 5. The figure of NGS is before the installation

Fig. 6. The figure of NGS at the neighbourhood of Gölbaşı-Şehitali after the installation

The figure of NGS at the neighbourhood of Gölbaşı-Şehitali is given at Figure 6 after it is installed.

Control and communications panel features for the NGR and NGS is given at the Table 2 [10].

Table 2. Control and communications panel features for the NGR and NGS

Control and communications panel features for the NGR and NGS		
	Sectionaliser (NGR)	Recloser (NGS)
Measuring	Voltage, Current, Power, Energy, Power Factor, Frequency, phase difference of the NGR in both directions, harmonics, and THB	Voltage, Current, Power, Energy, Power factor, Frequency
Control	Local / Remote selection, NGR Open/ Close, battery testing	Local / Remote selection, NGS Open /close, battery testing
Calculation	True RMS & RMS Values, Values and Harmonic Phase Angle	True RMS & RMS Values, Phase Angle
Protection	Phase or ground tripping with the option of fast and delayed option, Over current trip, sensitive earth-fault, Re-closer (4 times), Inrush limiting, Order Coordination, Overload protection	Fault detection (Phase / Ground), Sensitive earth-fault detection, load status, Inrush delay, On-line detection, live line indication
Status Monitoring	10 digital input contact, Isolator On / Off, gas pressure, NGR control lever is locked, the external power loss, low battery, cabin door is open	Isolator On / Off, Low Gas Pressure, NGS Control Arm locked, External Power Loss, Low Battery, Cabin Cover Open
Counter	Re-start counter, NGR open counter, fault detection counter	Re-start counter, NGS open counter, fault detection counter
Recorder	Time-tagged event records, fault records	Time-tagged event records, fault records
Communication Protocols	SCADA-DNP3.0, IEC60870-5 (optional) MODBUS-RTU	SCADA-DNP3.0, IEC60870-5 (optional) MODBUS-RTU

Standards

NGS and NGRs are produced in compliance with the international IEC 60298, IEC 60694, IEC 60529, IEC 62271–100, IEC 60265–1, IEC 61109. ANSI C37.60. The relevant international standards regarding the NGS NGR are given in Table 3 [10].

Table 3. International standards regarding the NGS NGR [10]

TS Number	International Standard	Name of the Standard
5248	IEC 60298	Metal-enclosed switchgear and control systems of which rated voltage is from 1 KV to 52 KV.
	ANSI/IEE C37.60	Automatic re-closing circuit breakers for alternate current systems
5278	IEC 60694	Common specifications for high voltage switching and control devices standards
3033	IEC 60529	Classification of degrees of protection provided by enclosures
3039	IEC 62271-100	High-voltage circuit breakers
	IEC 60265-1	High voltage switches of which rated voltage is from 1 KV to 52 KV.
	IEC 60376	New SF_6 gas properties
620	IEC 60044	Current transformers
718	IEC 60186	Voltage transformers
	IEC 61109	Composite type insulators for overhead line of which normal voltage is 1KV.
	IEC 60255	Relays
	IEC 60099-4	Metal-oxide surge arresters without gaps for alternative current systems

Recloser and Sectionalizer Opereting Logic

NGR opens the breaker in the case of 1st fault occurring on the line. And by turning into the normal position, it closes the breaker after the waiting time that is set. In the event that the fault continues in the case of the 2nd fault, it opens the breaker after the waiting time that is set. This situation continues until the set number of reclosing. In the event that the fault continues at the end of the set number of reclosing, NGR reaches the decision that there is permanent fault and it does not make reclosing operation, and leaves open the circuit. In Figure 7, this operation is illustrated [11].

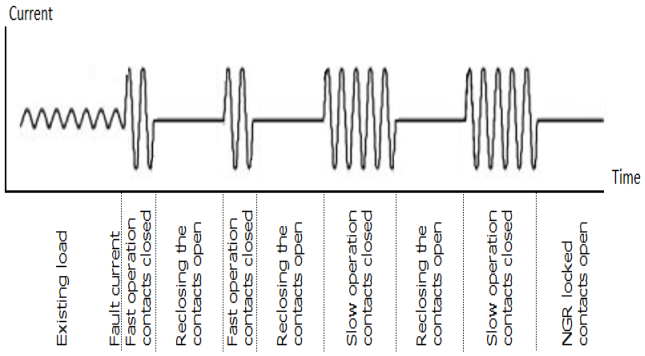

Fig. 7. Opening and reclosing of the NGR operation

The change is illustrated in Figure 8 during the operations of “opening" and" re-closing” of the NGR in the testing environment [9, 12].

Automatic load isolator (NGS) conducts automatic opening in connection with the re-closing breaker (NGR) that is on the side of the source after the fault incidents.

The current and voltage values shall be monitored by the fault detection unit via the current and voltage

transformations for this operation, and in the event that the decision is made upon the idea that the necessary conditions (source voltage zero, a current fault detected, the load isolator closed) are met, automatic closing shall be conducted [13-14].

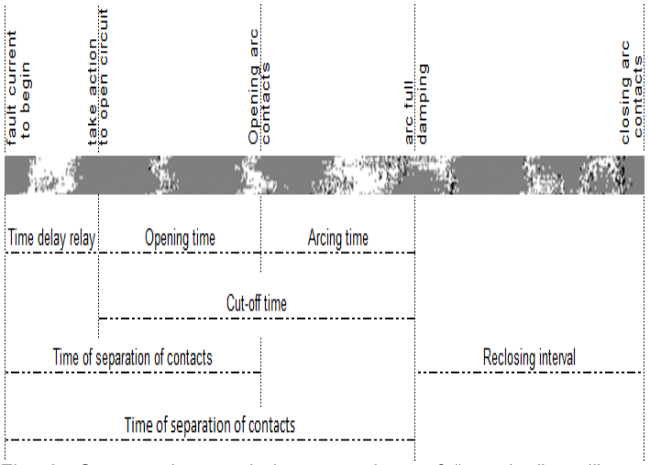

Fig. 8. Current change during operations of “opening" and" re-closing” of the NGR

The operation stages are given in the Figure 9 during the automatic opening when the NGS and the NGR operates synchronically.

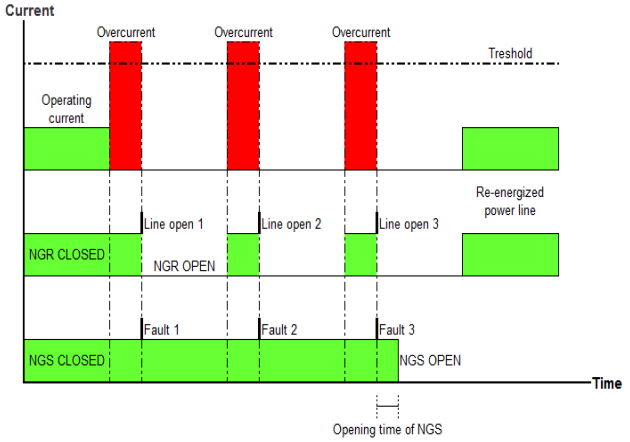

Fig. 9. The operation stages when the NGS and the NGR operates synchronically

The distribution chart showing the operation of NGS and NGR is given in Figure 10.

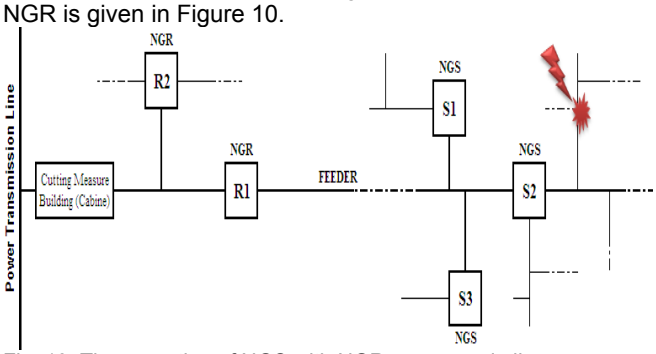

Fig. 10. The operation of NGS with NGR on a sample line

In the distribution chart that is illustrated in the Figure 9, when the fault circuit occurring on the point near S_2 (NGS) passes over, and R_1 (NGR) opens the circuit and closes the circuit after the waiting time. It records that a fault passes over S_2 and protects the position of energy. In the event that the fault continues, R_1 opens the circuit again. In the waiting time that is set before, S_2 opens itself provided that there is no voltage in the system. R_1 energizes the line again. By this way, since S_2 is open and the fault leaves the system, R_1 stays closed, energized in other words. All the other customers that are outside feeding from S_2, becomes energized. Since the faulted region is localized, the fault in the region shall be removed from the region by the fault line staff and S_2 shall be closed and by this way the system is energised.

Example Applications and Results

This study has been conducted in the capital city of Turkey, Ankara/Gölbaşı, İncek, Tuluntaş, Şehitali and Oğulbey that have been elected as pilot region and which have grid riot. It comprises of the results of the study at İncek cabine, Şehitali power transmission line which is continuing on cutting measure building, Gölbaşı Yağlıpınar-1 cabine, Karaoğlan cutting measure building and Oğulbey which includes 2 pieces of NGR and NGS. For Şehitali, the locations of the NGS and NGR on the line are given at Figure 11, and for Oğulbey the locations of the NGS and NGR on the line are given at Figure 12.

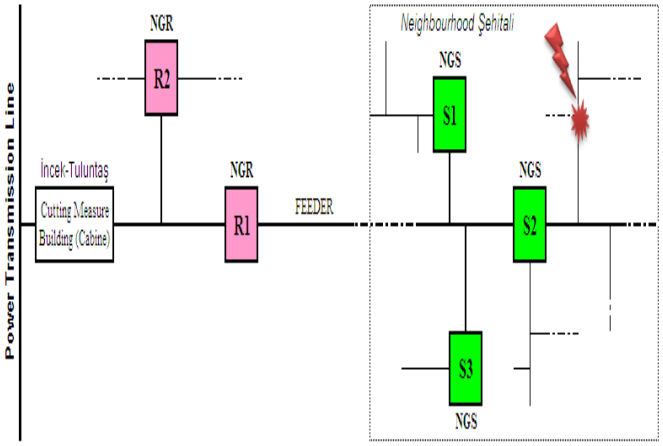

Fig. 11. The locations of the NGS and NGR on the line for Şehitali

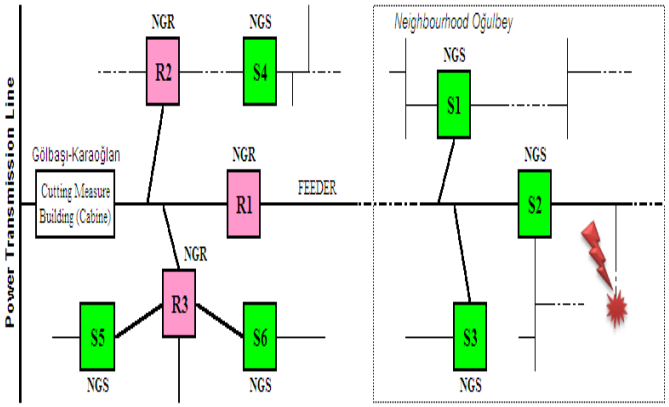

Fig. 12. The locations of the NGS and NGR on the line for Oğulbey

The change of permanent-temporary malfunction of NGR and NGS for the years of 2007-2008 at the routes of Ankara/Gölbaşı, Tuluntaş-Şehitali and Oğulbey-Yağlıpınar-I, is illustrated at the Table 4.

Conclusion and Recommendations

With the inclusion of NGR and NGS to the system, as can be seen from the date of the year of 2007, the number of the permanent malfunctions was 141 at the route of Tuluntaş-Şehitali and 127 at the route of Oğulbey - Yağlıpınar-I; and it was 9 at the route of Tuluntaş-Şehitali

and 7 at the route of Oğulbey - Yağlıpınar-I for the year of 2008. In other words, in 2007 the total number of malfunctions at the routes of two power transmission line at the town of Gölbaşı for the distribution system was 269; with the installation of NGR and NGS on those routes the permanent malfunction number decreased to 16, and by this way %93-%95 efficiency has been achieved. In 2007, temporary malfunctions affected the system as the permanent malfunctions did. In the assessment of the Table 4, while the total breaks duration was 32.640 minutes and the number of the subscribers without energy was 496 in 2007, the total breaks duration was 960 minutes and the subscribers that were affected from the break were 28 people in 2008. As can be seen from here, NGR and NGS's contribution is obvious for the organization engaged in the distribution or the company engaging in the electrics security for supply and the sale of the electrics.

Table 4. The malfunction change for the years of 2007-2008 with the NGR and NGS's inclusion to the system

NGR and NGS Installation Sites	2007 Year				2008 Year (NGR and NGS in the system)			
	Number of Malfunctions		Total Break Duration Minutes	App. Number of Subscribers without energy	Number of Malfunctions		Total Break Duration Minutes	App. Number of Subscribers without energy
	Permanent Malfunction (Number)	Temporary Malfunction			Permanent Malfunction (Number)	Temporary Malfunction		
Gölbaşı-Tuluntaş-Şehitali	141	All the malfunctions caused permanent malfunctions and they are tackled.	17.400	372	9	Not tackled. NGR and NGS offered solutions.	540	22
Gölbaşı-Oğulbey-Yağlıpınar-I	127	All the malfunctions caused permanent malfunctions and they are tackled.	15.240	124	7	Not tackled. NGR and NGS offered solutions.	420	6
Total	268		32.640	496	16		960	28

The results obtained from the investigations can be listed as following.

- The security supply of the system has increased. With the separation of the defective region from the system, few consumers have experienced power failure.
- The system's power failure time and the number of interruption are reduced. Due to legal sanctions, the related distribution company is saved from paying the financial penalties caused by power failures.
- Business expenses have decreased. Accordingly, the power transmission line maintenance costs are reduced; line switching and working life of the line elements are extended due to isolation elements are not exposed to fault currents.
- With inclusion of NGS and NGR in the system, the ability to flexible and easy protect is provided. Distribution network reliability and system stability is increased.
- These devices can be evaluated as an alternative option in trouble spots for expropriations as modular circuit-breaker cells. While the region of the Gölbaşı-Oğulbey neighborhood, where NGS is used, was a point that experienced the problem of expropriation, solution thus obtained without resorting to the option of expropriation.
- The detection of the defective place has become easier through the automation system. With control and communication unit that is provided with the NGS and NGR, fault detection, remote control option, control and measurement utility is provided on the system.

Acknowledgments thank you for your contributions to the General Directorate of TEDAŞ.

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