Local network deployed around the Kozloduy NPP - a useful tool for seismological monitoring

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Radiation risks may transcend national borders, and international cooperation serves to promote and enhance safety globally by exchanging experience and by improving capabilities to counter all hazards that may prevent accidents, to respond to emergencies and to mitigate any harmful consequences. International safety standards provide support for states in meeting their obligations under general principles of international law, such as those relating to environmental protection. Seismic safety is a key element of the NPP safety operation. Safety and security measures have in common the aim of protecting human life and health and the environment.

Kozloduy NPP Plc. is the only nuclear power plant in Bulgaria and the main electricity generating plant main providing more than one third of the total annual electricity output of the country. Safety is the main priority at Kozloduy NPP and it is a subject to independent state surveillance by the Nuclear Regulatory Agency at the Bulgarian Council of Ministers. Kozloduy NPP safety has been highly assessed and acknowledged internationally as a result of the reviews conducted in the last years, by teams of the International Atomic Energy Agency; World Association of Nuclear Operators (WANO); Atomic Questions Group of the European Commission etc. The electricity generation of Kozloduy NPP entirely fits into the World Nuclear Association’s concept of nuclear renaissance. The company meets the high environmental requirements of the Kyoto Protocol for it does not release any greenhouse gases into the atmosphere. Environmental protection is a fundamental issue in the company’s policy.

The Kozloduy NPP site is located in the stable part of the Moselorean platform (area of about 50,000 km²). From seismological point of view the Moselorean platform is the most quiet region on the territory of Bulgaria. There are neither historical nor instrumental earthquakes with M>4.5 occurred within the platform. The near region (area with radial extent of 30 km) of the NPP site is characterized with very low seismic activity. The strongest recorded quake is the 1897 earthquake M=3.8; located 22 km northwest of the Kozloduy NPP site on the territory of Romana.

As a key element of the NPP seismic safety, a local seismological network (LSN) of sensitive seismographs which have a recording capability for micro-earthquakes has been installed around Kozloduy NPP and has operational since 1997. The main goal of the local network is to supplement the available seismological data with more detailed information on small earthquakes occurring in the near region of Kozloduy NPP.

The LSN (presented in Fig.1) covers 3 seismic stations (SS: NPE, VLD and ORH) installed permanently within and close to the near 30 km region. At present NSGSS-BAS runs LSN around the Kozloduy NPP site. The operation and data processing, data interpretation, and reporting of the local micro-earthquake network are linked to the national seismic network (NOTSS). A real-time access to data from stations to National Data Center (in Sofia) was implemented using the VPN and MAN network links between the Bulgarian telecommunication. Real-time and interactive access to the current network information is provided by the Seismic Network Data Processor (SNDP) software package.

The results of more than 17 years of operation of LSN “Kozloduy” are presented in the figures Fig.4-6, all events (more than 80% of them are industrial explosions) localized in 150 km region surrounding Kozloduy NPP; and Fig.4-6(b)–more recent data recorded in 250 km region surrounding Kozloduy NPP from 1997 through 2014–impressive seismic activity developed in the SW margin of the region after the earthquake of moment magnitude 5.6 occurred on 23, May 2012. The earthquake is located at about 25 km south west of the city of Sofia.

Seismological equipment of the LSN seismic stations is presented in Fig.2. At the SS NPE the following is installed: Reflek digitizer DAS 130 1/3; broadband seismometer Relflek 155 with flat response from 120 s to 1 s and short period seismometer S1S with natural frequency of 1 Hz. Additionally, digitizer Basaid and short-period seismometer S1S are part of a part of Early Warning System (EWS) deployed in the territory of North Bulgaria and South Romania in the frame of the DGSCA project. The other SEPS, EU-funded short-system is installed at Kozloduy NPP in the frame of the same project. Equipment of VLD and SS consists of Basaid digitizer DAS 130 1/3 and short period seismometers S1S with natural frequency 1 Hz. The seismometers are situated in a borehole at the depth with 230 m at SS VLD while in SS ORH the seismometers are installed in a 5 m deep and well-constructed hole and calibrated to provide adequate information in line with updated international operational practices.

Fig.4a. Bulgarian seismological network and LSN located at Kozloduy NPP green points

The results of studies on seasonal variations in the noise levels at the three LSN stations are Illustrated in Fig.3. Increased level of seismic noise during the autumn-winter months in comparison to the summer and fall well observed at the 3 stations. That effect is related to the unstable and turbulent atmospheric processes during these seasons. VLD and ORH stations are situated in populated areas where the human activity on and near the Earth surface increases the noise level – it is seen in the frequency range below 1s. No human activity effects are observed at SS NPE and the curve of the power spectrum density of the noise lies close to the curve of the Low Noise (Brownian) noise floor, it is worth to mention that the NPE station is one of the quietest stations of Bulgarian Seismological Network.

The multiple studies carried out indicate that LSN jointly with NOTSS provide reliable registration of weak seismicity in the near (30 km) region of NPP site. Earthquakes recorded within and near the network are carefully analyzed in connection with seismotectonic studies of the near region. The seismological database acquired is homogeneous for the entire region to the extent possible or, at a minimum, is sufficiently complete for characterizing, from a seismotectonic point of view, features relevant to the site.

Fig.5. Equipment of the LSN Kozloduy seismic stations.

The geodynamic network in Bulgaria and the estimated horizontal velocities are presented in Fig.9. The velocity field shows predominant motion in South - Southwest to Southeast direction (relative to stable Eurasia) and increasing velocities from North to South conforming the extensional regime in Southeast Bulgaria and Northern Greece.

Fig.9. Seismicity in the LS region on the Kozloduy NPP (all months).

Time series (at 3 components) from ORH station observations for time period of five years are presented in Fig.10. Secular trend and annual variations are excluded.

The Kozloduy NPP region near east by intermediate-depth earthquakes occurred in the Vrancea seismogenic source (in Romania). The Vrancea seismogenic zone in Romania represents a specific for our region seismic source, which is a major concern for the most of the northern part of Bulgaria as well.

Fig.10. Time series for ORH station.

Situates at distance of more than 280 km away from the Vrancea zone, the Kozloduy NPP site may suffer damages due to high energy Vrancea intermediate-depth earthquakes. Digital records from the Kozloduy LSN stations recording earthquake in the Vrancea intermediate earthquake with magnitude Mw=5.6 occurred on 22.11.2014 at 10°14′ GMT are presented in Figs.8(a) and 8(b).

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