Experimental laboratory study of hydraulic fracture interaction with pre-existing fault.

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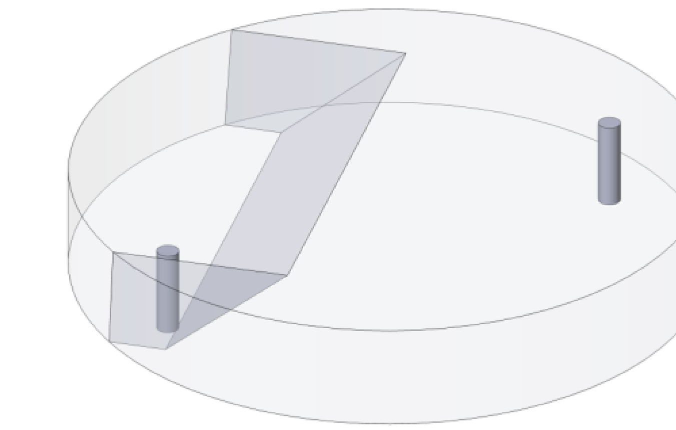

Fig.3. A diagram of the fracture creation.

Motivation

Hydraulic fracturing remains the primary method for increasing hydrocarbon field productivity. An essential aspect of hydraulic fracturing is considering natural fractures in rocks, which can enhance the efficiency of hydraulic fracturing or lead to unwanted consequences such as induced earthquakes.
We present the results of laboratory experiments investigating the interaction between hydraulic fracturing and a pre-existing fracture.

Description of Experimental Installations

The research was carried out with two experimental installations (Fig.1,2). The samples were made from a gypsum and cement mixture in a ratio of 10:1. The samples were saturated by silicone fluid with viscosity of 5 mPa·s. As a fracturing fluid, a silicone fluid with a viscosity of 0.5 Pa·s was used. The preliminary experiments were carried out using small-sized samples (∅104 mm, height 60 mm). The sample was placed between two aluminum disks with 6 integrated piezoelectric transducers and 4 displacement sensors. Two piezoelectric transducers in the upper disk sent ultrasonic pulses every 20 ms, four receivers in the lower disk registered the pulses.
The main experiments were carried out on a triaxial loading unit (Fig.2). The installation consisted of two steel discs (∅ 750 mm, thicknesses 75 mm), between which there was a steel ring (height 70 mm, internal ∅430 mm). There were several holes in the discs and the ring, which were used for mounting acoustic and pressure transducers, and pumping fluids in and out. The sample preparation was carried out in two stages to create a pre-existing fracture with the help of a wedge-shaped insert (Fig.3), which was removed after the first stage.

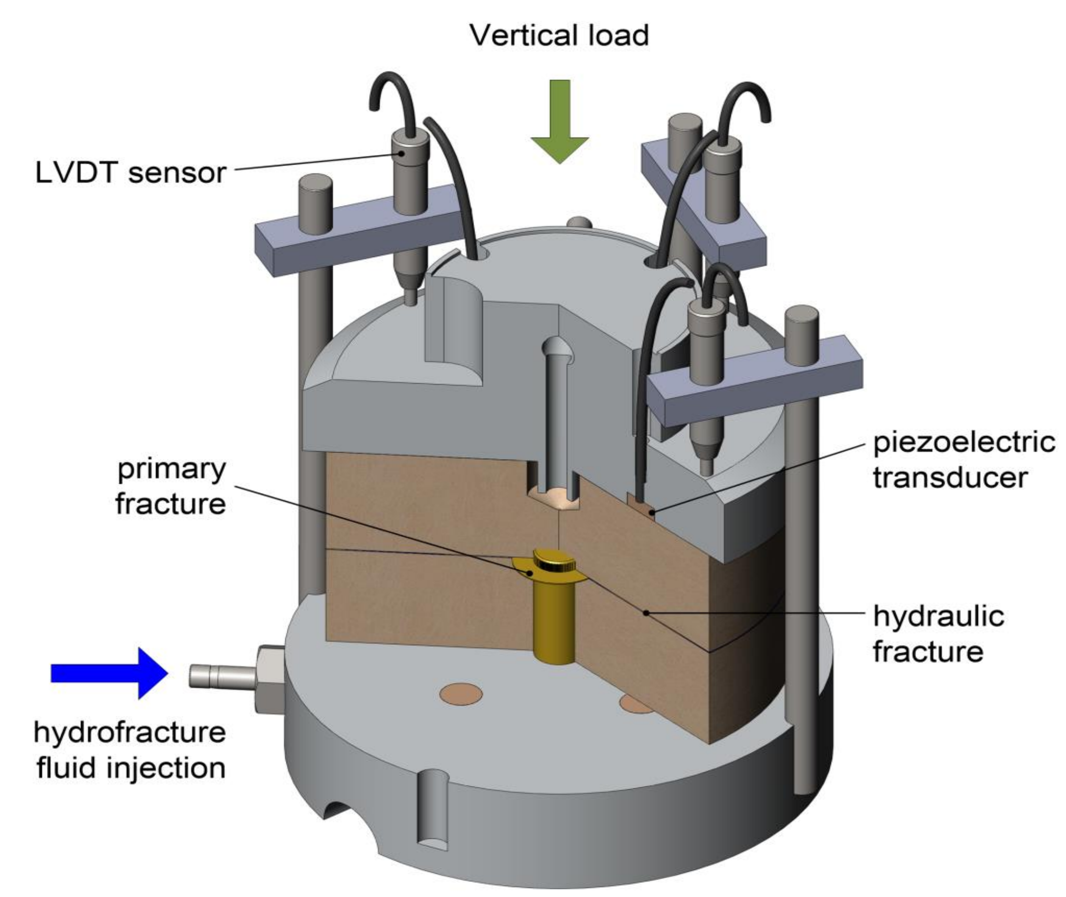

Fig.1. A diagram of installation for calibration experiments.

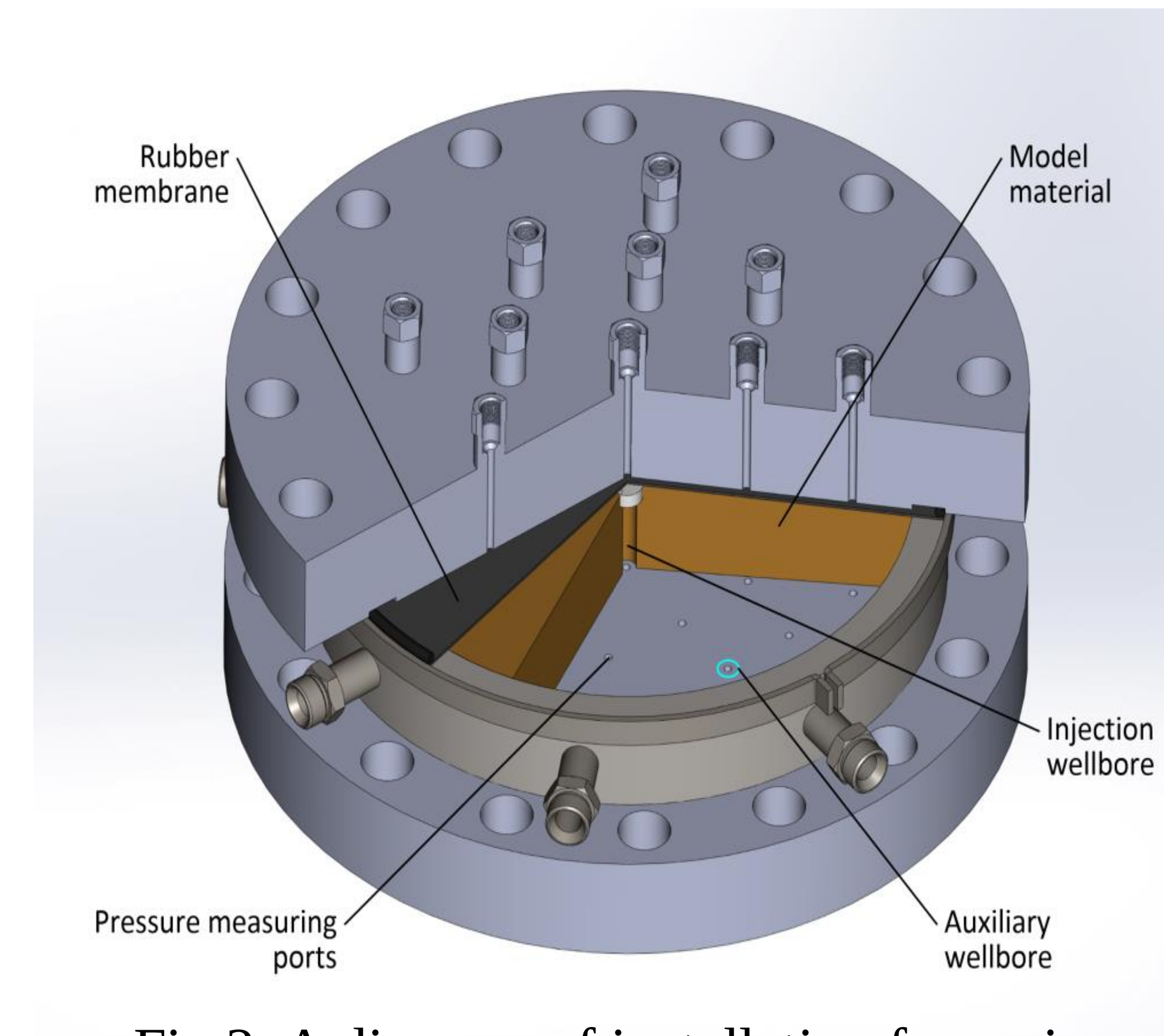

Fig.2. A diagram of installation for main experiments.

Results

Registered in preliminary experiments change in the injection pressure, the measured hydraulic fracture width, and the amplitude of the normalized transmitted ultrasonic are shown in Fig.4. The ultrasonic pulse amplitudes were compared with the fracture opening value (Fig.5). That relation was used for both hydraulic and pre-existing fracture opening estimations in the main experiments (Fig.6,7). The dependence of the natural fracture width on time and distance from its intersection by hydraulic fracture is shown in Fig.8.

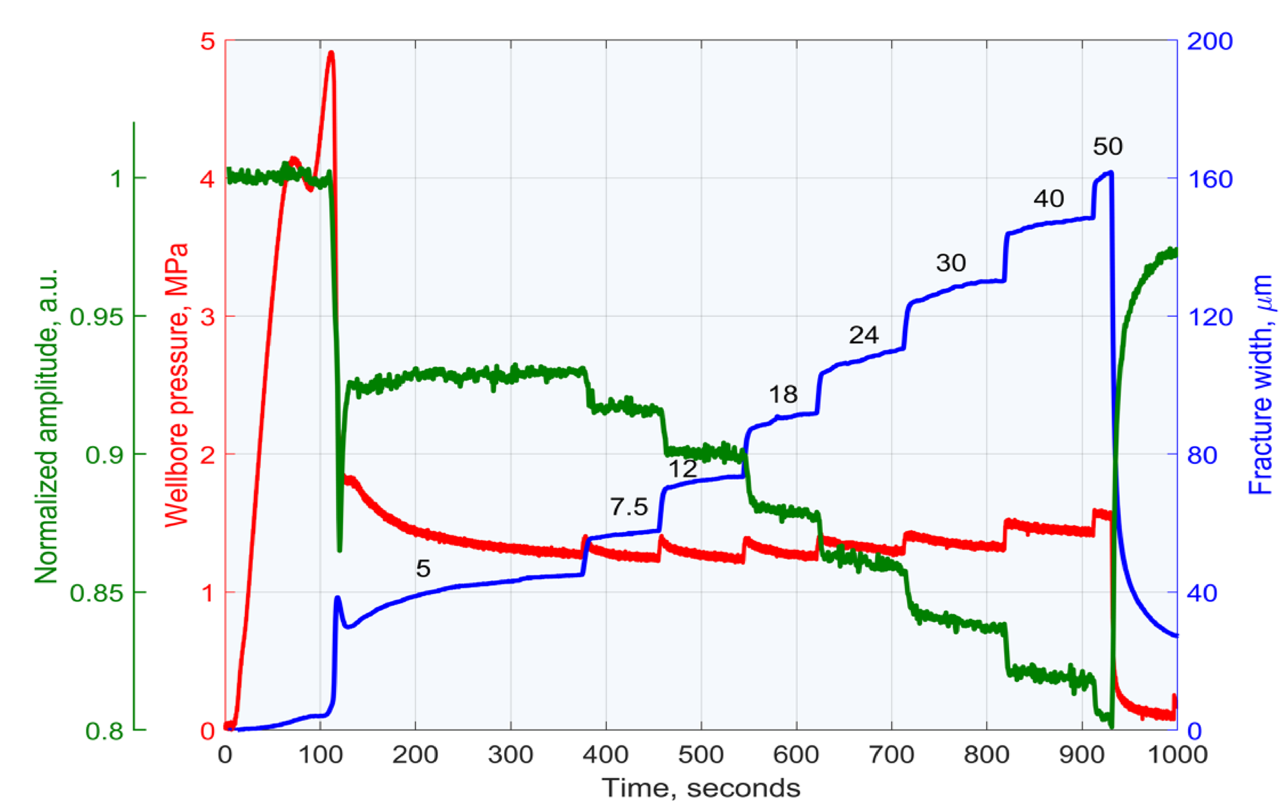

Fig.4. The injection pressure, the hydraulic fracture width, and the amplitude of the transmitted ultrasonic pulse variations in time. The numbers above the pressure curve show the flow rate of the fracturing fluid in mL/min.

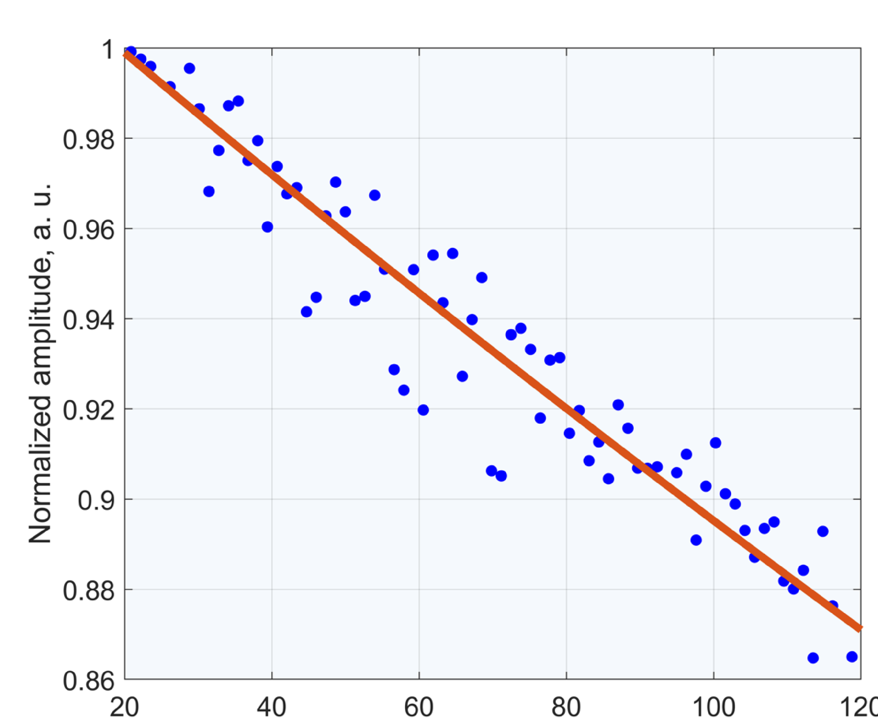

Fig.5. The relation between the normalized amplitudes of the ultrasonic pulses passing through the hydraulic fracture and the fracture width.

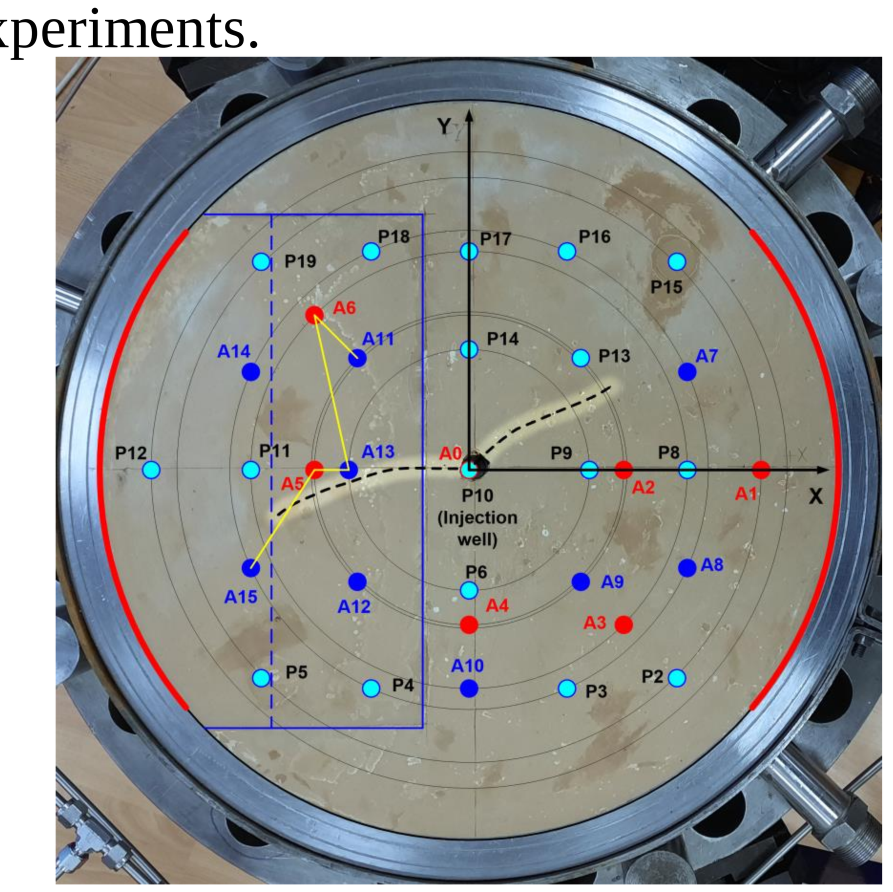

Fig.6. Photo of the sample after hydraulic fracturing (shown by the dashed lines). Blue lines show the pre-existing fracture. Transmitters at the top side of sample are show by red circles, receivers at the bottom – by dark blue circles.

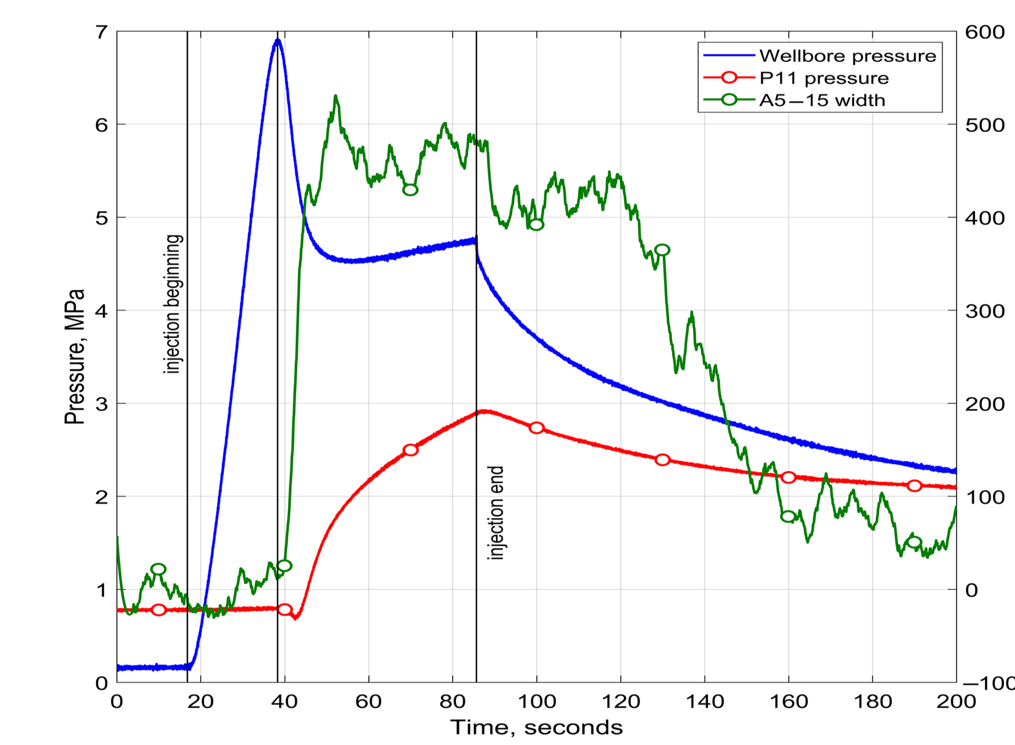

Fig.7. Dependences of the injection pressure, the pressure and the fracture width along the "natural" fracture on time.

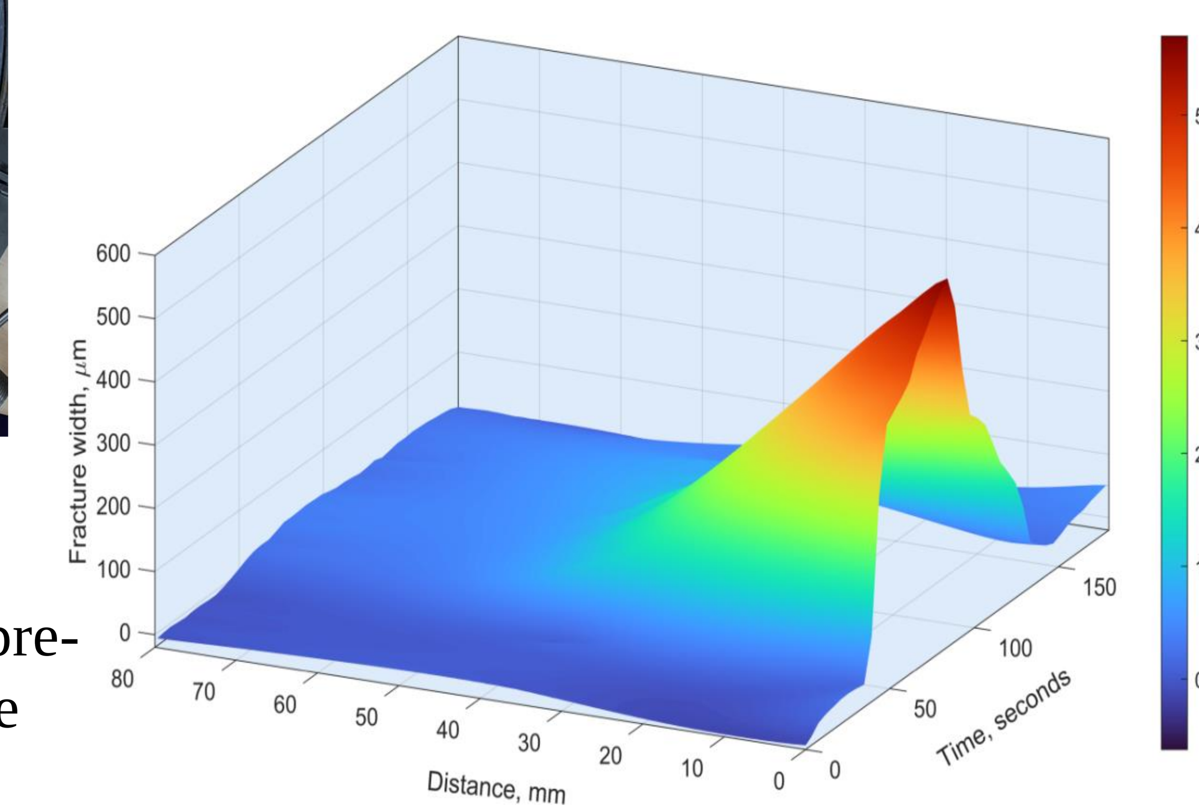

Fig.8. The dependence of the width of the natural fracture on time and distance

Conclusions

Ultrasonic monitoring of both hydraulic fractures and natural fractures, supplemented by the results of preliminarily conducted calibration experiments, allowed us to estimate the hydraulic fracture and natural fracture width changes during injections. Both fractures formed a united hydraulic system that reacted almost simultaneously to the injection. We believe that our results can be used for the validation of numerical simulations of the interaction between hydraulic fractures and natural fractures.

Zenchenko, E.V.; Turuntaev, S.B.; Nachev, V.A.; Chumakov, T.K.; Zenchenko, P.E. Study of the Interaction of a Hydraulic Fracture with a Natural Fracture in a Laboratory Experiment Based on Ultrasonic Transmission Monitoring. Energies ***2024****, 17, 277. https://doi.org/10.3390/en17020277*