EXPERIENCE IN INCREASING THE FLEXIBILITY OF THE POWER SYSTEM OF KAZAKHSTAN

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01 Conditions for stable operation of a wind power plant depending on voltage.

02 The range of regulation of the reactive power of a solar power plant from its actual output

03 Operation under frequency fluctuations

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>Minimum operating time</th>
</tr>
</thead>
<tbody>
<tr>
<td>47.0 Hz – 49.0 Hz</td>
<td>120 minutes</td>
</tr>
<tr>
<td>49.0 Hz – 51.0 Hz</td>
<td>Unlimited</td>
</tr>
<tr>
<td>51.0 Hz – 51.5 Hz</td>
<td>90 minutes</td>
</tr>
</tbody>
</table>
Due to the lack of flexible generation in Kazakhstan, there is a problem in maintaining a balance between electricity generation and consumption. Due to the intermittent generation and increasing proportion of RES, power imbalances also increase. All imbalances in the power system of Kazakhstan are addressed by power flows from the power system of Russia. However, with unscheduled flows of more than 1,000 MW, both overhead lines at the Kazakhstan-Russia border and overhead lines in the Russian power system may be overloaded.
CHALLENGES (2/2)

WITH THE INTRODUCTION OF RE

Reducing the inertia of the power system

Generator rotor angles under disturbance without RES

Generator rotor angles during disturbances after the introduction of RES
AUTOMATION SYSTEMS. FACTS (1/4)

Local emergency control devices protect only a limited area of the electrical network

Resource intensive process of setting up automation, static settings of emergency automation

Centralized Emergency Automatic System

Now
Centralization of emergency control devices, automatic maintenance of power system reliability

Automatic selection of emergency control settings

Automatic monitoring of the circuit-regime situation of the UES of Kazakhstan, continuous calculation and adjustment of emergency automation in real time

Emergency control corresponding to the current circuit-mode situation and the severity of the emergency shutdown

In case of emergency

In case of emergency

Specialists in electrical modes service of the System
Operator calculate the settings of emergency automatics once every 2 years

Operating personnel at the substation configure emergency automatic devices

Emergency control in accordance with pre-configured emergency automation

Internal: This information is accessible to ADB Management and staff. It may be shared outside ADB with appropriate permission.
AUTOMATION SYSTEMS. FACTS (2/4)

As it was
Control of power balance in the power system based on commands from dispatch personnel

Emergence of power imbalance in the power system

The National Dispatch Center of the System Operator gives a command to change the flexible generation

Regional dispatch centers transmit command to the power plant

Power plants (subject to agreements)

Due to time losses (transfer of dispatchers’ command, long reaction of personnel at the station), a limited number of power plants with contracts for the provision of services to the System Operator for regulation, a significant part of the imbalance is regulated by the Russian power system in order to maintain frequency

Now
Ensuring power balance in the power system in automatic mode

Emergence of power imbalance in the power system

AGC automatically sends commands to change flexible generation

Automatic control of the production-consumption balance, efficient use of regulatory capacities (part of the imbalance is still eliminated by the Russian energy system due to the lack of flexible capacities in the UES of Kazakhstan)
AUTOMATION SYSTEMS. FACTS (3/4)

As it was

Use of grid based on operating calculations

Electrical mode specialists of the System Operator set network limitations from reliability standards once every 2 years (according to legal regulations)

Operating personnel at the substation configure emergency automatic devices

Operating personnel at the substation configure emergency automatic devices

Now

Maximize grid using through real-time control

WAMS automatically monitors modes

WACS carries out emergency control in real time
**Magnetically controlled shunt reactor.**

500 kV: -180 MVAR. 220 kV: -100+30 MVAR

To stabilize voltage, reduce losses and increase the reliability of operation of long transmission lines. Controlled shunt reactors are electromagnetic reactors, the inductance of which can be smoothly adjusted using an automatic control system. This is achieved by saturating the magnetic system with controlled magnetic fluxes, which makes it possible to regulate and stabilize the voltage. Also used in combination with capacitor banks connected in parallel, as a result of which the required voltage is maintained on the lines.

**Phase-shifting transformer.**

500 kV, 400 MVA

Phase-shifting transformers provide active power flow control. By enforcing or blocking loads, they improve the stability and flexibility of grids and help to get the most out of existing hardware.
CONCLUSION

Kazakhstan has set ambitious goals to increase the share of RE. At the same time, the power system of Kazakhstan is experiencing problems in maintaining the power balance. The implemented automatic systems and FACTS make it possible to improve the conditions for the integration of RE.
Thank you