

**SC B2 Overhead Lines  
PS1 Overhead Lines for high power transfer capacity**

**Compact controllable 110 – 500 kV overhead lines**

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Nowadays modern overhead transmission lines (OHL) constructions having several significant differences from conventional ones are being used in power grids more and more widely. Implementation of compact overhead lines equipped with FACTS devices, including phase angle regulator settings, appears to be one of the most effective ways of power grid development.

To date, a 25-year-long successful experience of 110 – 330 kV compact OHLs including compact controllable OHLs has been obtained in CIS. In UES of Russia the 330 kV compact OHL Pskovskaya GRES – Novosokolniki with total length of 146.7 km has been successfully operated since 1993. The compact controllable OHL's creation experience and operation showed the possibility of significant technical and economic effect in the transmission of a required power amount compared to the conventional design OHLs. For example, the initial capital cost of 110 kV double-circuit compact OHL construction with increased 1.3 times natural loading operated in Moldova power system is 12% lower compared to the conventional double-circuit OHL.

Compact controllable OHLs are the new generation of alternating current power transmission lines, represented the most new advances in the field of power transmission and means of regulation, new technical solutions for the design, insulation, connection layouts and control systems.

The main distinctive features of the compact controllable OHLs are:

- extremely reduced phase-to-phase distances adopted in compliance with the minimal required insulation distances (dielectric strength of the "phase-to-phase" gaps) at maximum operating voltage and also under lightning and commutation overvoltage;
- optimal design of split phases subjected to the existing requirements of limiting the maximum electric field strength on conductor's surfaces at levels below permissible under the terms of the corona appearance;
- new phase configurations, where tower's grounded parts (poles, cross-arms, suspension hubs) placed outside of the interphase space;
- insulating elements (insulating spacers or ties) between closely adjacent OHL phases installation if required, fixing the selected distance between phases and dampening conductor's vibration or galloping under severe weather conditions, which ensures high mechanical stability and reliability of the adjacent phases in spans;

– angular phase shifts establishment between the voltage vectors applied to the compact controllable OHL adjacent phases : for three-phase single-circuit compact controllable OHLs phase shift value is equal to  $120^\circ$  between three adjacent phases, for double-circuit compact controllable OHLs – phase shift value could vary within the range of  $0 \div 120^\circ$  or  $0^\circ \div 180^\circ$  or be fixed  $120^\circ$  or  $180^\circ$  between two adjacent phases of different circuits in order to keep  $120^\circ$  between the voltage vectors inside the circuit;

– implementation of high-speed phase control devices and adjustable compensation devices ( FACTS type).

A number of patents and copyright certificates on inventions in the field of compact controllable power transmissions is obtained.

Compared to the conventional overhead lines, compact controllable ones with FACTS devices provide the following:

- 1.2-1.6 times increase in capacity;
- reduction of total costs per transmission capacity unit by 10 – 20%;
- 1,5-2 times alienated land reduction in case of equal power transmission;
- reduction of EMF in the OHL external space, and therefore environment and inhabitants impact decreasing;
- ability to control power flows and their directions;
- the reactive power control devices efficiency increase;
- total energy losses reduce in the power system;
- increase of OHL's mechanical strength under severe weather conditions.

Advantages of 220 and 500 kV compact overhead lines against conventional lines were studied in several Russian power systems taking into account its projected future development.

During researches carried out, various compact 220 and 500 kV overhead line configurations with variable number of conductors per bundle, bundle conductor spacing, phase-to-phase distance and phase location were examined and the most effective variants of compact lines construction of 220 and 500 kV compact OHL with both optimal technical characteristics and minimized environmental impact were defined. Advantages of 220 and 500 kV compact overhead lines against conventional lines were studied.

Application of compact OHL provides:

- building cost economy per 1 MW of its natural loading up to 37% for 220 kV OHL and up to 33% for 500 kV OHL;
- right-of-way reduction per 1 MW of its natural loading is up to 36% for 220 kV transmission lines and up to 42% for 500 kV lines.

The results obtained also showed that control devices total capacity and therefore its costs for compact OHL versus conventional ones would be considerably lower.

Transmission capacity of compact OHL equipped with FACTS devices is close to one of conventional lines of higher voltage level. The researches carried out showed that technical, economic and ecological parameters appeared to be significantly higher for compact controllable OHL of various voltage levels against conventional lines' parameters. Conclusion about OHL design should be made on the basis of compact controllable OHL versus conventional one feasibility study subject to substation equipment costs.