At the end of 1999, four series capacitors rated together at 430 Mvar and supplied by ABB were commissioned together with the 4th line of Transener’s 500 kV AC power transmission corridor, enabling vast amounts of hydro power to be transmitted from the Comahue region in south western Argentina to the large consumer areas around Buenos Aires, a distance of more than 1000 km. Transmission is performed by means of four parallel 500 kV AC lines, all series compensated.

With the 4th line in operation, the overall power transmission capacity of the system has been increased by 1300 MW, to a total of 4600 MW.

Totally, there are 10 ABB series capacitors in operation in the power corridor, altogether rated at close to 2500 Mvar at 500 kV. The purpose of the series compensation of the four lines is to enable an increase of the active power transmission capability of the power corridor, a task which is fulfilled in several ways at the same time:

- by raising the transient stability limit of the lines;
- by improving the reactive power balance and voltage regulation of the lines;
- and by improving the active power sharing between the lines.
The 4th line, which is of compact design, represents the most recent step in the history of expanding the Comahue-Buenos Aires power transmission corridor which has been going on since the late 1970s, and which has enabled a power transmission increase from 1650 MW in the first stage to 4600 MW with the fourth, series compensated line in operation.

**Comprehensive compensation**

In addition to series compensation, part of the ABB undertaking with the 4th line was also the supply and commissioning of a number of switched shunt reactors with ratings between 150 Mvar and 250 Mvar (3-phase) at the intermediate transformer stations (altogether over 700 Mvar) to limit the voltage rise during low load conditions. Also part of the undertaking was relay protection of the line, line communication equipment of fibre optic type, as well as switchgear equipment for upgrading of existing substations.

Furthermore, two SVC (Static Var Compensators) each rated at –160/+160 Mvar, also supplied by ABB, have been in operation at the receiving end of the corridor since 1983 for dynamic control of the voltage and power factor in the system.

**Less lines needed due to series capacitors**

Without the series capacitors, several additional 500 kV lines would have had to be built to enable stable transmission of the same amount of power through the corridor. This would have been unpermissible, from an environmental, concessional as well as economical point of view. As a matter of fact, the benefits of series compensation as an alternative to building of lines were established from the very start, when an evaluation was made between two series compensated 500 kV lines and three uncompensated lines, for transmission of the initial 1650 MW of power. The series compensated alternative came out considerably less costly, and with this, the series capacitor option was firmly established for the continued development of the power corridor.

**Evolution of the series compensated corridor**

All in all, the evolution / expansion procedure over the years can be summarized as follows:

- **Mid 70s:** 1st and 2nd lines in operation, including 4 series capacitors (Puelches, Henderson); Total power transmission capacity: \( \sum P = 1650 \text{ MW} \).
- **Mid 80s:** 3rd line in operation.
- **Mid 90s:** 4 series capacitors added to the 3rd line (Olavarría, Choele Choel); Power transmission capacity increased to \( \sum P = 2900 \text{ MW} \).
- **1996:** 1st and 2nd line series capacitors upgrade (Puelches and Henderson); Power transmission capacity further increased to \( \sum P = 3300 \text{ MW} \).
- **1999:** 4th line in operation, including 4 series capacitors (Olavarría, Choele Choel); Overall power transmission capacity \( \sum P = 4600 \text{ MW} \).

Ratings of individual series capacitors range from less than 100 Mvar to close to 700 Mvar.

A future additional extension of the series compensation of the power corridor has been prepared for, to enable an overall power transmission capacity of the four lines of 5200 MW.

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**Evaluation of original AC transmission system options.**

**Series capacitor single-line diagram**

Installation cost. The blue box in “A” designates series capacitors cost.
Series capacitor scheme
The 10 series capacitors are all protected by means of zinc-oxide varistors, protecting the capacitors in the event of faults in the transmission system. In case of external faults, i.e. faults not located in the same line section as the series capacitor, the series capacitor is reinserted into the circuit instantaneously upon clearing of the fault. This safeguards the highest possible dynamic stability of the system.

In cases of internal faults, i.e. faults located inside a series compensated line segment, the series capacitor is allowed to be bypassed, and is reinserted in due course after reinsertion of the faulted line.

Control and protection system
The series capacitor control and protection system is microprocessor based and uses optical current transducers for current measurement with optical fibres for signal transmission. This system offers several benefits:

- No relay protection equipment is located on the EHV platforms;
- No auxiliary power is required on the platforms;
- The optical current transducers are powered solely by means of light generated at ground level.

Furthermore, maintenance costs are reduced by continuous self monitoring. Maintenance intervals are increased by the use of the self monitored digital microprocessor based system.

The control and protection system supervises all functions of the series capacitor and provides protective action in the event of faults such as capacitor overload or unbalance, spark gap flashover and varistor overload.

For accomplishing this, several quantities are measured by means of digital optical current transformers (DOCT):
- Line current
- Capacitor unbalance current
- Spark gap current
- Varistor current
- Platform flashover current.

The DOCT consists of a current transducer in the high voltage current busbar and an optical interface module in the control room. In the transducer, the current is sampled and converted to a digital value. This value is transmitted in the fibre optical system to the interface. The converter circuit in the transducer is optically powered by light sent from the interface to the transducer in the same fibre which transmits the measured value.

The transducer is operated at a sampling rate of 2000 Hz, using low powering levels for the converter circuit. This allows low power laser diodes to be used as supply power source.

<table>
<thead>
<tr>
<th>Technical data series capacitors</th>
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</thead>
<tbody>
<tr>
<td>System voltage</td>
</tr>
<tr>
<td>Type of protection</td>
</tr>
<tr>
<td>Puelches Henderson</td>
</tr>
<tr>
<td>Varistor rating, MJ (3-phase)</td>
</tr>
<tr>
<td>Degree of comp, %</td>
</tr>
</tbody>
</table>
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