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DC SYSTEMS & POWER ELECTRONICS

10570_2022

HVDC Link Benefits for the AC Transmission System Operation. Technical and Economic Aspects

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Motivation

- This work explores the benefits that can be obtained in a conventional alternating current electrical power system (HVAC) by means of proper operation of a direct current transmission link (HVDC). The technical and economic advantages of HVDC systems compared to HVAC are well known mainly for their convenience for long distances and large power transmissions; however, a study dedicated to the operation criteria of HVDC links may maximize its benefits. Some examples includes: power loss minimization for the entire interconnection system, reduction in the number of operation of compensation equipment (shunt reactors and capacitors, series capacitors bypass, tap changer movement) and extension of its life cycle, reducing maintenance costs, and better performance of existing control and automatic schemes through joint coordinated operation of the HVDC link in disturbances events scenarios, minimizing the impact on the system.

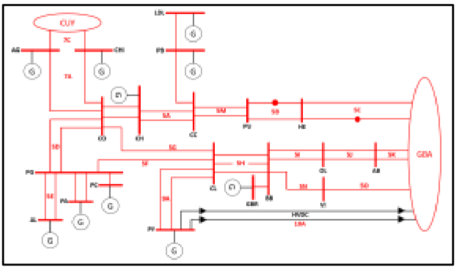
Objects of investigation

- To demonstrate additional technical and economic advantages of HVDC systems in the operation of HVAC systems in addition to the already known benefits of this technology.

Method/Approach

- Network Losses: The HVDC link was modeled in future scenarios considering important volumes of hydro and wind generation dispatch in the Patagonia - Comahue - Buenos Aires areas, where it was possible to obtain the losses in the SADI as a function of the power dispatched by the HVDC link, increasing power steps of 100MW per pole.

- The new DAGCOM AGD scheme will include in its decision matrix the transmission power over the HVDC link, being able to use the remaining capacity in it to compensate post-fault overloads depending on the type of event occurred.



Experimental setup & test results

- Setting the operating point of the HVDC link as the one representing the lowest losses for the network, a reduction is found in the maneuvers required in the network reactive power compensation equipment for the same generation levels under study.

- The transmission power of the HVDC link with minimum losses is between 1100 MW and 1200 MW per pole.

- With the operation of the HVDC link within the AC system, the maneuvers in the system compensation equipment are reduced to 31.3%. This reduction in maneuvers implies a great economic gain for the system, by extending the useful life of the equipment, avoiding short-term replacements and extending the maintenance period of the equipment.

- Starting from a predefined value of 1100 MW per pole, a new DAGCOM AGD scheme acting as a function of events was analyzed and an efficiency factor called F_(Eficiency_HVDC) was defined, which allows comparing the traditional methodology with the proposed modulation of the transmission power by the HVDC link.

$$F_{Eficiency_{HVDC}} = \left(1 - \frac{P_{AGD_{selection_{HVDC}}}}{P_{AGD_{selection}}}\right) * 100\ [\%]$$

$$\forall\ P_{AGD_{selection_{HVDC}}} > 0$$

Conclusion

- Among the results obtained, it was possible to verify that many of the post-fault overloads evidenced could be cushioned by increasing HVDC transmission, thus achieving a more efficient machine selection (a smaller number of units to be disconnected), and in some cases it allows the possibility of solving minor overloads by applying Automatic Generation Reduction (AGR) logics.

- Losses in the AC network can be considerably reduced with an adequate dispatch of the HVDC system.

- The number of maneuvers of the reactive power compensation equipment is strongly reduced by using the HVDC link as a complement, extending the useful life of the equipment and delaying maintenance, reducing the unavailability of the equipment.

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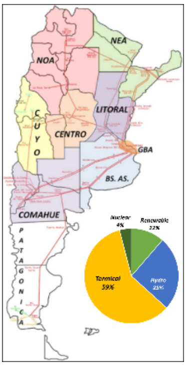
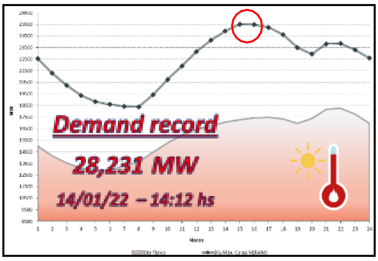
The Argentine Interconnection System (SADI)





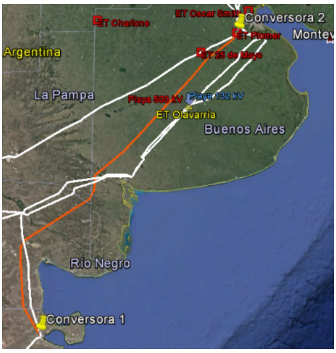
Transmission system, installed capacity and current demand

Future Status

Area	Inst. Capacity november 2021 [MW]	Gen. Projects [MW]	Inst. Capacity 2026 [MW]	Dem. 2026 [MW]
Buenos Aires	8.203	1.314	9.517	3.946
Centro	3.240	556	3.796	2.829
Comahue	7.110	1977	9.087	1.100
Cuyo	2.107	923	3.030	2.021
GBA	8.063	369	8.432	12.555
Litoral	4.027	4429	8.456	4.269
NEA	3.132	1413	4.545	2.416
NOA	4.354	500	4.854	2.644
Patagonia	2.647	2.240	4.887	1.329
Total SADI	42.883	13.721	56.604	33.341

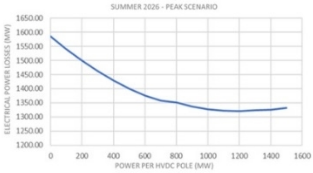
MODEL GENERATION AND DEMAND VALUES

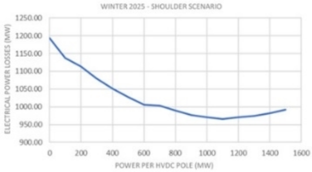
HVDC Link

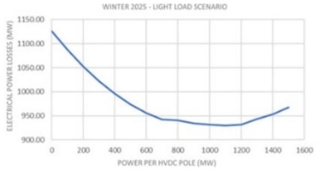


LCC technology of ± 600 kV - 3000 MW - 1200 km

Operation and dispatch of the HVDC link – Network Losses







Network losses in relation to HVDC link modulation

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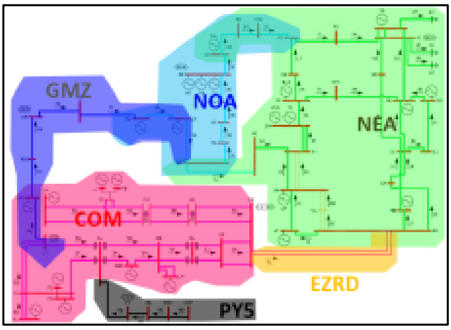
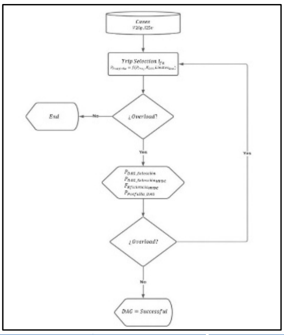
AGDCOM Scheme / Event-driven programming and effectiveness





Study case	Simple fault link AC	Overload	Withuot HVDC link	With HVDC link		HVDC Link efficiency [%]
			PAGD [MW]	PAGD_HVDC [MW]	HVDC Modulation [MW]	
Summer peak 2026	5M	Paralell corridor	690	210	800	69,6
	5J	Paralell corridor	560	0	700	100
Winter shoulder 2025	5D	5F	670	0	0	0
	5F	5D	95	0	0	0
	5F	5A	120	0	270	100
	HVDC Link Pole 1	5M	200	12	400	94

Reduction of maneuvers in minimum loss dispatching

Maneuvers withiot HVDC link	Busbar	Summer peak 2026	Summer light load 2026	Winter peak 2025	Winter shoulder 2025	Winter light load 2025	Total maneuvers per year
Additional connection of 1 Step SB Santa Cruz Norte shunt busbar reactor	12	X					300
Additional connection of 1 Step SB Barrancosa shunt busbar reactor	26	X					300
Shunt busbar reactor disconnection SB Chocón	1000					X	430
Shunt busbar reactor disconnection SB Choele Choel	1008		X		X	X	730
Shunt busbar reactor disconnection SB Puelches	1026		X		X	X	730
Shunt busbar reactor disconnection SB Puelches	1028		X	X	X		730
Shunt busbar reactor disconnection SB Bahía Blanca	2000		X		X	X	730
Adjustment to 1 Step of Shunt busbar reactor SB Henderson	2004		X	X			730
Adjustment to 1 Step of Shunt busbar reactor SB Henderson	2006		X	X			730
Adjustment to 1 Step of Shunt busbar reactor SB Olavarría	2008				X	X	430
Shunt busbar reactor disconnection SB Olavarría	2008			X			430
Shunt busbar reactor disconnection SB Charlone	2040				X	X	430
Shunt busbar reactor disconnection SB Vivorata	2050		X	X	X		730
Shunt busbar reactor disconnection SB Lujan	6010		X		X	X	730
Shunt busbar reactor disconnection SB Rio Diamante	7002		X		X	X	730
Shunt busbar reactor disconnection SB Rodeo	7011		X		X	X	730

Maneuvers	Busbar	Summer peak 2026	Summer light load 2026	Winter peak 2025	Winter shoulder 2025	Winter light load 2025	Total maneuvers per year
Shunt busbar reactor disconnection SB Chocón	1000					X	430
Shunt busbar reactor disconnection SB Choele Choel	1008					X	430
Shunt busbar reactor disconnection SB Puelches	1026				X	X	430
Shunt busbar reactor disconnection SB Henderson	2006		X				430
Shunt busbar reactor disconnection SB Lujan	6010				X	X	430
Shunt busbar reactor disconnection SB Rio Diamante	7002				X	X	430
Shunt busbar reactor disconnection SB Rodeo	7011				X	X	430