Deliverable 2.1.2

Detailed Project Description

04 - DZIT Algeria - Italy

EC DEVCO - GRANT CONTRACT: ENPI/2014/347-006

"Mediterranean Project"

Task 2 "Planning and development of the Euro-Mediterranean Electricity Reference Grid "

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1 Introduction

The present document contains the studies on project DZIT, in the context of the Mediterranean Master Plan of Interconnections. Project DZIT consists of an interconnection between Italy and Algeria (+1000 MW DC).

The document is structured as follows. Section 2 describes in detail the interconnection project and the different sources for data employed. Section 3 presents the definition of the different snapshots to be considered and the description of the building process followed. Section 4 comprises the criteria and results of the security analysis. Section 5 summarizes the results on security analysis and reinforcements' assessment. Section 6 contains the estimations made for the active power losses. Finally, section 7 comprises the estimation for the different investment costs.

2 Project description and data acquisition

The project consists in a new interconnection between Algeria and Sardinia to be realized through an HVDC submarine cable, with an ampacity of 1000 MW.

Project details							
Description	***Substation (from)***	***Substation (to)***	***GTC contribution (MW)***	***Present status***	***Expected commissioning date***	***Evolution***	***Evolution driver***
New interconnection between Italy and Algeria (HVDC)	Cagliari Sud (*) Sardinia (IT)	Cheffia (*) Algeria	1000	Long-term project	Post 2030	In addition to the last study performed by Sonelgaz and TERNA on 2014, an updated study was promoted by both companies and performed within the Mediterranean project n°I of Med-TSO.	Increase the NTC in the Mediterranean countries and providing mutual benefits according the complementary characteristics of both countries and therefore best optimizing economic opportunities of energy exchange

(*) Terminal substations are preliminary hypothesis

The system defined for project DZIT is described in the table and figure below.

Full models	Boundaries
Italy IT	France FR
Tunisia TN	Switzerland CH
Algeria DZ	Austria AT
	Slovenia SI
	Montenegro ME
	Greece GR
	Libya LY
	Morocco MA

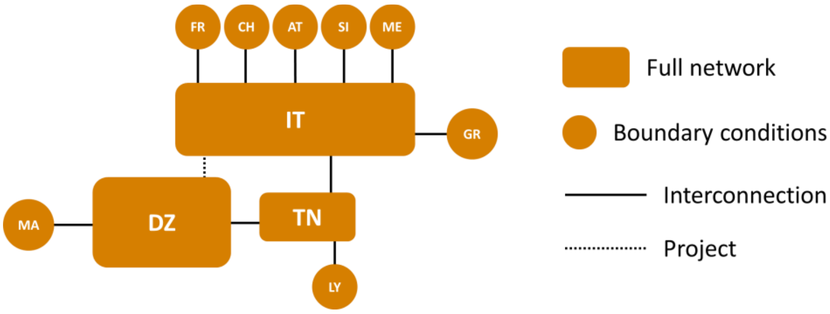

Table 1 – Participation of each of the systems involved in project DZIT

For this project, the Algerian, Tunisian and Italian systems have been considered as full represented by their transmission network models. Boundary systems, i.e. Morocco, Libya, France, Switzerland, Slovenia, Montenegro and Greece, are considered as external buses with loads to simulate energy interchanges.

In the snapshots definition, 4 scenarios (S1, S2, S3 and S4) and seasonality (Winter/Summer) are distinguished. Models provided:

- For the Algerian system, a set of eight models have been provided, corresponding with 4 scenarios (S1, S2, S3 and S4) and seasonality (Winter/Summer).
- For the Tunisian system, a set of four models have been provided, corresponding with 4 scenarios (S1, S2, S3 and S4)
- For the Italian system a set of two models have been provided, one for scenarios S1 and S2 and the other for scenarios S3 and S4.

Full list of provided files is included in [1].In all models provided interconnected Areas are well identified. Generating technologies are identified in the 'Owner' field for Machines. Concerning merit order list, all generating units are considered with the same rank. Certain particularities in the models provided for the three systems involved in the project are mentioned below:

DZ: The file '0.DZ_Database guidline&Market data_Common cases_S&W-Peak.xlsx' provided contains a complete guideline for the format used to collect network information, plus the generation dispatch by technologies, demand and energy interchanges for S1-S4 and S/W. Concerning Algerian areas (4th character in bus code), from 1 to 7 have been identified as Algerian areas. Rest of them represent boundary countries, i.e. 'M' for Morocco and 'T' for Tunisia. Finally, 'S' represents the Algerian bus for DZES project, while 'I' represents the Algerian bus for DZIT project. Finally, in the uploaded EXCEL files, generating technologies are identified using numbers. The following table identifies the Algerian nomenclatures and the standard form.

Technologies Identified in EXCEL networks	Standard technologies
NUCLEAR	1 – NUCLEAR
CCGT - OLD	13 - GAS CCGT OLD 2 (45% - 52%)
CCGT - NEW	14 - GAS CCGT NEW (53% - 60%)
OCGT- OLD	17 - GAS OCGT OLD (35% - 38%)
WIND	26 - WIND ONSHORE
PV	23 - SOLAR PHOTOVOLTAIC
CSP	24 - SOLAR THERMAL
Hybrid	24 - SOLAR THERMAL
SVC	(Static Var Compensator → 99-UNKNOWN)
SLACK	Connection with Morocco (slack of the system)

TN: the file 'Mapping_file_for_TN.XLSX' provided contains information on generating units' characteristics and dispatch for the four scenarios.

IT: Additionally, the file 'Generators technology.xlsx' provided contains basic information on generating units of the Italian system. Generating technologies are well identified in the 'Owner' field for Machines, but using ENTSO-E codes. File 'Generators technology.xlsx' includes the matching between ENTSO-E codes and Med-TSO codes. Concerning merit order list, all generating units are considered with the same rank. Finally, the file 'IT_interconnections.xlsx' provided comes with basic information on interconnections of the Italian system.

Merging process consists of joining the different networks using the connecting buses defined in the next tables. First, Table 2 summarizes the interconnections between systems, which correspond with pairs of modelled systems, thus two interconnection buses must be identified, one for each of the systems in the interconnection.

Bus	Area	Substation	Bus	Area	Substation
CHE3112	Algeria DZ	Chefia	JENT112	Tunisia TN	Jendouba
EAO3212	Algeria DZ	El Aouinet	TAJT211	Tunisia TN	Tajerouine

Table 2 – Points of merging between systems in the DZIT project

Table 3 shows the set of interconnections that correspond with pairs formed by a modelled system and a boundary system, thus only one bus in the modelled system needs to be identified.

Bus	Area (from)	Substation	Area (to)
BOUM111	Algeria DZ	Boussidi	Morocco MA
OUJM211	Algeria DZ	Oujda	Morocco MA
XWU_SO21	Italy IT	Soverzene	Autria AT
XNA_GL21	Italy IT	Glorenza	Autria AT
XLI_PO21	Italy IT	Pordenone	Autria AT
XGR_TA41	Italy IT	Taio	Autria AT
XSO_ME11	Italy IT	Mese	Switzerland CH
XSI_VE1I	Italy IT	Verderio	Switzerland CH
XSE_PA21	Italy IT	Pallanzeno	Switzerland CH
XRO_SF11	Italy IT	S. Fiorano	Switzerland CH
XRO_GO11	Italy IT	Gorlano	Switzerland CH
XRI_VA21	Italy IT	Valpelline	Switzerland CH
XRI_AV21	Italy IT	Avise	Switzerland CH
XME_CA11	Italy IT	Castasegna	Switzerland CH
XLA_MU11	Italy IT	Musignano	Switzerland CH
XGO_ME21	Italy IT	Mese	Switzerland CH
XCA_ME21	Italy IT	Castasegna	Switzerland CH
XAL_PO21	Italy IT	Ponte	Switzerland CH
XVL_VE12	Italy IT	Venaus	France FR
XGR_PI9I	Italy IT	Piossasco	France FR
XB._CA21	Italy IT	Camporoso	France FR
XAL_RO12	Italy IT	Rondisone	France FR
XAL_RO11	Italy IT	Rondisone	France FR
XAR_GA1I	Italy IT	Galatina	Greece GR
XVI_TI9I	Italy IT	Villanova	Montenegro ME
XRE_DI11	Italy IT	Redipuglia	Slovenia SI
XPA_DI21	Italy IT	Padriciano	Slovenia SI
XBE_SA1S	Italy IT	Salgareda	Slovenia SI
ABOU KAMMECH	Tunisia TN	Abou Kammech	Libya LY
ROUIS	Tunisia TN	Rouis	Libya LY

Table 3 – Points of merging between systems and external buses in the DZIT project

For the interconnection between Algeria and Morocco (boundary), two buses have been identified in Algerian networks as part of the Moroccan network, BOUM111 and OUJM211. However, it is important to remark that bus OUJM211 appears disconnected, since all the energy transfers between Morocco and Algeria are through BOUM111.

Finally, Table 4 presents the new interconnections associated to the DZIT project.

PROJECT	Bus	Area	Subs.	Bus	Area	Subs.	LINK
DZIT	ITAI111	Algeria DZ	Koudiet	SELCTI38	Italy IT	Sarlux	HVDC

Table 4 – Points of merging in the Projects in the DZIT project

Projects DZIT involve one HVDC link between Algeria and Italy. Buses in the Algerian side (ITAI111) and the Italian side (SELCTI38) have been identified. The AC/DC substation in Algerian side will be connected to the Algerian grid through two OHL 400 kV, (44 km each one). In the case of Sardinia, it is important to remark that the point Cagliari Sud is purely indicative.

3 Snapshots definition and building process

For the project DZIT, a total number of nine Points in Time (PiT) have been defined [2]. Each of the PiT contains, for each of the systems considered, the active power generated, demanded and exported to the other systems. Active power production comes with a breakdown of technologies. Next table shows the power balance for each of the PiTS in DZIT project.

project DZIT PiT 1 - Power Balance [MW]

sys	PG	PD	Pexport	DZ	IT	TN	FR	CH	AT	SI	ME	GR	MA	LY
Algeria DZ	13446.9	12827.0	619.9	0.0	558.5	300.0	0.0	0.0	0.0	0.0	0.0	0.0	-238.6	0.0
Italy IT	22298.4	31598.0	-9299.6	-558.5	0.0	600.0	-4350.0	-3009.8	-348.5	-357.0	-1154.2	-121.6	0.0	0.0
Tunisia TN	2327.7	2727.7	-400.0	-300.0	-600.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	500.0

project DZIT PiT 2 - Power Balance [MW]

sys	PG	PD	Pexport	DZ	IT	TN	FR	CH	AT	SI	ME	GR	MA	LY
Algeria DZ	24267.0	23967.0	300.0	0.0	-1000.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	1000.0	0.0
Italy IT	34159.8	44284.1	-10124.3	1000.0	0.0	600.0	-599.3	-6240.0	-1655.0	-1530.0	-1200.0	-500.0	0.0	0.0
Tunisia TN	3750.3	4150.3	-400.0	-300.0	-600.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	500.0

project DZIT PiT 3 - Power Balance [MW]

sys	PG	PD	Pexport	DZ	IT	TN	FR	CH	AT	SI	ME	GR	MA	LY
Algeria DZ	20841.4	18541.3	2300.0	0.0	1000.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	1000.0	0.0
Italy IT	36103.8	50836.0	-14732.2	-1000.0	0.0	0.0	-4350.0	-6240.0	-1655.0	-1486.0	-44.1	42.8	0.0	0.0
Tunisia TN	4898.7	4698.8	200.0	-300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	500.0

project DZIT PiT 4 - Power Balance [MW]

sys	PG	PD	Pexport	DZ	IT	TN	FR	CH	AT	SI	ME	GR	MA	LY
Algeria DZ	23895.3	23595.3	300.0	0.0	1000.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	-1000.0	0.0
Italy IT	45867.7	56478.4	-10610.7	-1000.0	0.0	214.2	-2611.3	-2432.2	-1655.0	-1427.9	-1198.5	-500.0	0.0	0.0
Tunisia TN	4654.3	4668.5	-14.2	-300.0	-214.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	500.0

project DZIT PiT 5 - Power Balance [MW]

sys	PG	PD	Pexport	DZ	IT	TN	FR	CH	AT	SI	ME	GR	MA	LY
Algeria DZ	29759.1	29459.1	300.0	0.0	1000.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	-1000.0	0.0
Italy IT	52170.8	54429.9	-2259.1	-1000.0	0.0	600.0	-596.5	-1245.7	-405.2	0.0	388.3	0.0	0.0	0.0
Tunisia TN	6428.2	7131.9	-703.7	-300.0	-600.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	196.3

project DZIT PiT 6 - Power Balance [MW]

sys	PG	PD	Pexport	DZ	IT	TN	FR	CH	AT	SI	ME	GR	MA	LY
Algeria DZ	25419.2	25559.3	-140.1	0.0	-1000.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	559.9	0.0
Italy IT	53528.8	51088.0	2440.8	1000.0	0.0	600.0	1789.2	-523.3	-595.1	-1530.0	1200.0	500.0	0.0	0.0
Tunisia TN	6058.9	6458.9	-400.0	-300.0	-600.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	500.0

project DZIT PiT 7 - Power Balance [MW]

sys	PG	PD	Pexport	DZ	IT	TN	FR	CH	AT	SI	ME	GR	MA	LY
Algeria DZ	29959.4	27676.5	2282.9	0.0	1000.0	282.9	0.0	0.0	0.0	0.0	0.0	0.0	1000.0	0.0
Italy IT	44614.6	48790.8	-4176.1	-1000.0	0.0	-23.8	-4279.3	0.0	0.0	115.7	511.3	500.0	0.0	0.0
Tunisia TN	5134.6	4893.6	240.9	-282.9	23.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	500.0

project DZIT PiT 8 - Power Balance [MW]

sys	PG	PD	Pexport	DZ	IT	TN	FR	CH	AT	SI	ME	GR	MA	LY
Algeria DZ	29174.3	26874.3	2300.0	0.0	1000.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	1000.0	0.0
Italy IT	45039.8	48214.9	-3175.1	-1000.0	0.0	600.0	454.9	0.0	0.0	-1530.0	-1200.0	-500.0	0.0	0.0
Tunisia TN	4702.7	5102.7	-400.0	-300.0	-600.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	500.0

project DZIT PiT 9 - Power Balance [MW]

sys	PG	PD	Pexport	DZ	IT	TN	FR	CH	AT	SI	ME	GR	MA	LY
Algeria DZ	14502.4	15359.2	-856.9	0.0	-1000.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	-156.8	0.0
Italy IT	41762.1	39425.6	2336.5	1000.0	0.0	600.0	-1603.3	0.0	544.2	95.6	1200.0	500.0	0.0	0.0
Tunisia TN	2879.8	3279.8	-400.0	-300.0	-600.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	500.0

Table 5 – Power balance for each of the PiTS defined in the DZIT project

4 Power flow and security analysis

This section presents the criteria agreed to run the power flow and N-x contingency analysis over the different snapshots built for project DZIT. Details on the methodology used for the security analysis are compiled in [3].

Algeria

For the Algerian system, the N-1 will be focused on the transmission levels. Therefore, the branches considered for the N-1 analysis are only those at 220 kV and 400 kV. Also, overloads will only be checked for branches at 220 kV and 400 kV.

Concerning rates and tolerances, PSS/E files come with three different values, i.e. rateA, rateB and rateC. For lines, rateA will be considered for Winter, rateB will be considered for Summer, and rateC will be unused. For transformers, rateA will be considered as unique rate, thus rateB and rateC will be unused. The tolerance for overload will be 0% for all branches, in N and N-1 situations.

Regarding the loss of generating units, the energy lost will come from the Moroccan interconnection, until rate. Then, if it is necessary, the rest of the energy lost will come from Italy through Tunisia, via the TNIT interconnection.

Finally, no N-2 situations have considered for Algeria.

Tunisia

For the Tunisian system, the N-1 will be focused on the transmission levels. Therefore, the branches considered for the N-1 analysis are only those at 150 kV, 225 kV and 400 kV. Also, overloads will only be checked for branches at 150 kV, 225 kV and 400 kV.

Concerning rates and tolerances, PSS/E files come with three different values, i.e. rateA, rateB and rateC. For lines and transformers, rateA will be considered all snapshots, thus rateB and rateC will be unused. The tolerance for overload will be 0% for all branches in N, and +20% in N-1 situations.

Regarding the loss of generating units, the energy lost will come first from Italy, via the TNIT interconnection, until rate. Then, if it is necessary, the rest of the energy lost will come from Morocco through Algeria.

Finally, no N-2 situations have considered for Tunisia.

Italy

For the Italian system, the N-1 will be focused on the transmission levels. Therefore, the branches considered for the N-1 analysis are only those at 150 kV, 220 kV, 400 kV and 500 kV. Also, overloads will only be checked for branches at 132 kV, 150 kV, 220 kV, 400 kV and 500 kV.

Concerning rates and tolerances, PSS/E files come with three different values, i.e. rateA, rateB and rateC. For lines and transformers, 1.2 times the rateA will be considered for Winter and 0.8 times the rateA for Summer. Thus, rateB and rateC will be unused. The tolerance for overloads in lines will be 0% for N and N-1 situations. The tolerance for overloads in transformers will be 0% for N and +10% for N-1 situations.

Regarding the loss of generating units, it depends. If the generating unit belongs to the Sardinia subsystem, the energy lost will be compensated by using the rest of Sardinian generating units, and the interconnection with the peninsula if it is necessary. For peninsular generating units, the energy lost will be compensated by using the rest of peninsular generating units.

Finally, the set of N-x outages is defined by considering simultaneous outage of each couple of branches with a degree of separation from the interconnections less or equal to two.

5 Assessment of reinforcements

For the interconnection project between Algeria and Italy, no severe overloads have been detected due to the new interconnection for neither the Italian nor Tunisian systems. Therefore, no reinforcements were defined for neither of them.

In the case of the Algerian system, some overloads are detected in the area between Ramdane Djamel and Berrahl substations. These overloads appear in 220 kV network under the outage of 400 kV circuits RDN – BRH. To solve this situation, a single reinforcement has been defined to be analyzed. This reinforcement consists of doubling the 400 kV 65 km circuit between BRH3111 (Berrahal) and RDN3112 (Ramdana).

Next figure shows the map of the projected interconnection (violet line), and corresponding reinforcements (red line).

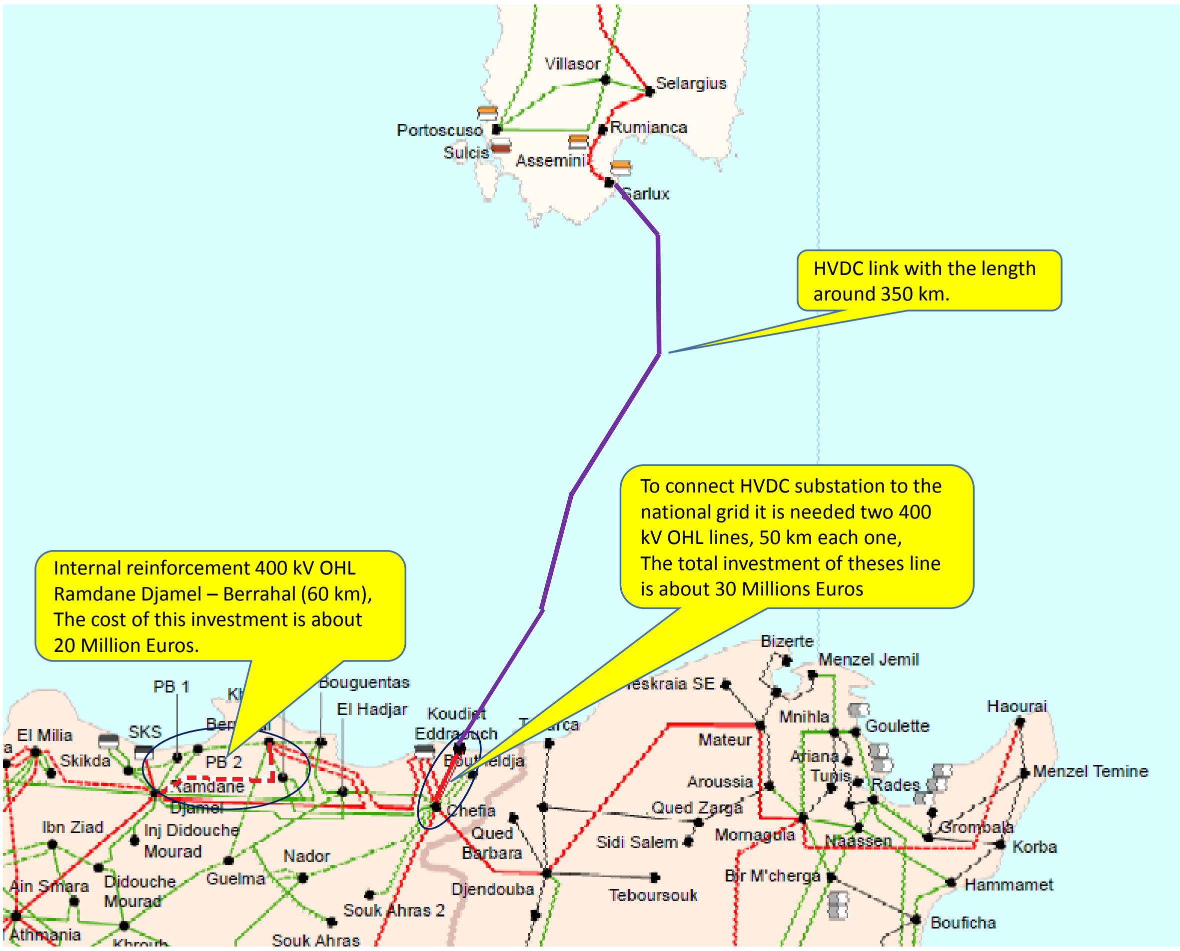

Figure 1 – Map of interconnections and reinforcements for project DZIT

6 Estimation of Active Power Losses

Internal losses in each country

To evaluate the performance of the new interconnection projects plus the planned reinforcements, the active power losses have been computed for 1) the snapshots built with the specified reinforcements considered, and for 2) the snapshots without interconnection projects and without reinforcements. Next tables show the active power losses summary for each of the PiTs, Table 6 with the results for the Algerian system, Table 7 with the results for the Tunisian system and Table 8 with the results for the Italian system.

	Power losses [MW]		
PiT	Without proj&reinf	With proj&reinf	Difference (W-WO)
1	101.8	121.7	19.9
2	330.5	336.8	6.3
3	230.3	249.7	19.4
4	361.8	431.2	69.4
5	485.4	503.5	18.1
6	328.5	323.8	-4.7
7	411.7	458.8	47.1
8	350.1	410.1	60.0
9	205.3	174.8	-30.6

Table 6 – Comparison of the active power losses for each snapshot, with and without interconnection projects and reinforcements, for the Algerian system

	Power losses [MW]		
PiT	Without proj&reinf	With proj&reinf	Difference (W-WO)
1	99.8	103.3	3.4
2	92.5	94.8	2.2
3	81.7	83.5	1.8
4	60.7	68.3	7.6
5	71.0	73.7	2.7
6	80.3	87.3	7.0
7	94.9	98.7	3.8
8	66.9	73.8	6.9
9	54.9	52.8	-2.1

Table 7 – Comparison of the active power losses for each snapshot, with and without interconnection projects and reinforcements, for the Tunisian system

	Power losses [MW]		
PiT	Without proj&reinf	With proj&reinf	Difference (W-WO)
1	667.1	696.4	29.2
2	598.4	686.6	88.2
3	980.9	945.5	-35.4
4	569.8	577.0	7.2
5	309.7	274.3	-35.4
6	304.1	290.7	-13.4
7	742.2	715.5	-26.7
8	352.7	341.5	-11.2
9	502.9	556.4	53.6

Table 8 – Comparison of the active power losses for each snapshot, with and without interconnection projects and reinforcements, for the Italian system

Considering the time percentile (hours of the year) that each PiT represents, internal active power losses with and without the new interconnection project computed for each PiT have been converted to annual energy losses for each one of the 4 scenarios.

Losses in the new HVDC interconnection

Based on the hourly time series of exchange among countries provided by Market studies for each one of the 4 scenarios, with and without the new interconnection project, yearly losses on the interconnection have also been computed.

Computation of the losses in the new HVDC interconnection has been carried out for the four scenarios S1 to S4 and 8760 hours of estimated flows through the interconnections. The following table summarizes the values used for this estimation exercise, considering 400 kV and 500 kV as potential nominal voltage for the projected link:

V (kV)	r_1 (Ω/100km)	A (MW/kA)	B (MW)	d (km)
400	1.10	1.5	3.4	350
500	0.57	2.2	5.0	

Table 9 – Parameters for the DZIT HVDC link loss estimation

The following table shows the annual losses estimate for the HVDC link and scenario:

Scenario	Annual Losses (GWh)	
	400 kV	500 kV
S1	288	210
S2	281	207
S3	288	210

S4	283	207

Table 10 – Annual losses estimate for the new DZIT HVDC link

7 Estimation of Investment Cost

The new HVDC link between Algeria and Italy consists of 350 km of VSC bipolar undersea cable. Using 1.50 M€/km for the cost of the cables including installation, the estimate for the cable cost is 525 M€. The estimated cost for the two converters is 270 M€. To connect HVDC substation to the Algerian grid two 400 kV OHL lines, 44 km each one + two AIS line bay at Koudiet substation are needed, for a total cost of 32.6 M€. Finally, the total investment cost in the new HVDC interconnection is 828 M€.

The election of the VSC technology over the LCC technology are listed below [4]:

- Active and reactive power can be controlled independently. The VSC is capable of generating leading or lagging reactive power, independently of the active power level. Each converter station can be used to provide voltage support to the local AC network while transmitting any level of active power, at no additional cost;
- If there is no transmission of active power, both converter stations operate as two independent static synchronous compensators (STATCOMs) to regulate local AC network voltages;
- The use of PWM with a switching frequency in the range of 1–2 kHz is sufficient to separate the fundamental voltage from the sidebands, and suppress the harmonic components around and beyond the switching frequency components. Harmonic filters are at higher frequencies and therefore have low size, losses and costs;
- Power flow can be reversed almost instantaneously without the need to reverse the DC voltage polarity (only DC current direction reverses).
- Good response to AC faults. The VSC converter actively controls the AC voltage/current, so the VSC-HVDC contribution to the AC fault current is limited to rated current or controlled to lower levels. The converter can remain in operation to provide voltage support to the AC networks during and after the AC disturbance;
- Black-start capability, which is the ability to start or restore power to a dead AC network (network without generation units). This feature eliminates the need for a startup generator in applications where space is critical or expensive, such as with offshore wind farms;
- VSC-HVDC can be configured to provide faster frequency or damping support to the AC networks through active power modulation;
- It is more suitable for paralleling on the DC side (developing multiterminal HVDC and DC grids) because of constant DC voltage polarity and better control.

The following tables provide an estimate for the investment cost for the internal reinforcements, and the Cost Benefit Analysis (CBA). It should be noted that this is an estimation of the cost based on the best practices in the region.

P4 - DZIT - Investment Cost								
New Interconnections								
Description	**Type**	**Countries Involved**	**Length/number**		**Total Investment Cost**	**GTC Contribution**	**Location**	**Status**
			OHL [km]	**Cable [km]**	**M€**	**MW**		
New Interconnection DZ-IT	HVDC Submarine Cable VSC bipolar	DZ-IT		350	525	1000	NE DZ - S Sardinia (IT)	Long-term
	AC-400 kV OHL	DZ	100		30			
	Tow (02) AIS baie 400 kV OHL	DZ	2		2.6			
	HVDC Converter Station	DZ	1		135		NE DZ	Long-term
	HVDC Converter Station	IT	1		135		S Sardinia (IT)	Long-term
Total Cost of New Interconnections (M€ / %total)					**828**	**98%**		
Internal Reinforcements								
Description	**Type**	**Countries Involved**	**Length/number**		**Total Investment Cost**	**Capacity**	**Location**	**Status**
			OHL [km]	**Cable [km]**	**M€**	**MW / MVA**		
New 400 kV OHL	AC OHL 400kV - 2-bundle	DZ	60		18.0	1000-1200	NW DZ	Long-term
	Tow (02) AIS baie 400 kV OHL	DZ	2		2.6			
Total Cost of Internal Reinforcements (M€ / %total)					**21**	**2%**		
Total Project Investment Cost					**848**			

Table 11 – Investment cost of the project DZIT

Assessment results for the Cluster P4 - DZIT														
non scenario	GTC increase direction 1 (MW)		1000											
	GTC increase direction 2 (MW)		1000											
scenario specific			MedTSO scenario											
			1			2			3			4		
			Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta
GTC / NTC (import)		DZ	1300	2300	1000	1300	2300	1000	1300	2300	1000	1300	2300	1000
		ITn	10625	11625	1000	10625	11625	1000	10625	11625	1000	10625	11625	1000
		ITs												
Interconnection Rate (%)*		DZ	2.6%	4.7%	2.0%	2.5%	4.3%	1.9%	1.9%	3.4%	1.5%	2.0%	3.6%	1.6%
		ITn	8.9%	9.7%	0.8%	9.0%	9.9%	0.8%	7.7%	8.4%	0.7%	7.5%	8.2%	0.7%
		ITs												
Benefit Indicators	B1-SEW	(M€/y)	160			130			250			140		
	B2-RES	(GWh/y)	340			630			2000			1300		
	B3-CO_2	(kT/y)	2200			-700			400			-350		
	B4 - Losses**	(M€/y)	13.9			26.2			7.9			25.8		
		(GWh/y)	214			391			82			385		
	B5a-SoS Adequacy	(MWh/y)	0			0			0			0		
	B5b-SoS System Stability													
Residual Impact Indicators	S1- Environmental Impact													
	S2-Social Impact													
	S3-Other Impact													
Costs	C1-Estimated Costs	(M€)	848											

* considering the GTC for 2030 , the Install generation for 2030 and the GTC for importation (the same criteria used in the ENTSO-E)

** Estimation of losses in the HVDC interconnection considered VSC technology (bipolar 400 kV)

Rules for sign of Benefit Indicators

B1- Sew [M€/year] =	Positive when a project reduces the annual generation cost of the whole Power System
B2-RES integration [GWh/Year] =	Positive when a project reduces the amount of RES curtailment
B3-CO_2 [kt/Year] =	Negative when a project reduces the whole quantity of CO_2 emitted in one year
B4-Losses - [M€/Year] and [GWh/Yea	Negative when a project reduces the annual energy lost in the Transmission Network
B5a-SoS [MWh/Year] =	Positive when a project reduces the risk of lack of supply

Assessment	Color code
negative impact	(red)
neutral impact	(light pink)
positive impact	(green)
Not Available/Not Available	(grey)
monetized	(yellow)

Table 12 – Results of the Cost Benefit Analysis for the *DZIT* project

8 References

1	Snapshots building process	Share point
2	Guide for setting up grid models for Network studies V 5.0	Share point
3	Network Analysis and Reinforcement Assessment	Share point
4	D. Jovcic and K. Ahmed, “Introduction to DC Grids,” in High-Voltage Direct-Current Transmission, John Wiley & Sons, Ltd, 2015, pp. 301–306.	Share point

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