Deliverable 2.1.2

Detailed Project Description

07 - DZTN Algeria - Tunisia

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

“Mediterranean Project”

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

Med-TSO is supported by the European Union.

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1 Introduction

The present document contains the studies on project DZTN, in the context of the Mediterranean Master Plan of Interconnections. Project DZTN consists of a new interconnection between Algeria and Tunisia (+700 MW AC).

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 Tunisia, with an ampacity of 700 MW. It is due to the important hours of saturation that were detected in the preliminary market simulations that this cluster was added. Physically, it consists on a second 400 kV OHL from the substation Jendouba in Tunisia to the substation Chefia in Algeria.

Project details							
Description	***Substation (from)***	***Substation (to)***	***GTC contribution (MW)***	***Present status***	***Expected commissioning date***	***Evolution***	***Evolution driver***
New interconnection between Algeria and Tunisia (AC)	Algeria (DZ) Chefia	Tunisia (TN) Jendouba	700	Mid or long-term project	*n.d.*	A new study was promoted by Sonelgaz and STEG, and performed within the Mediterranean project n°I of Med-TSO.	Increase the existing NTC between the two countries and providing mutual benefits according the complementary characteristics of both countries and therefore best optimizing economic opportunities of energy exchange

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

Full models	**Boundaries**
Algeria DZ	Italy IT
Tunisia TN	Morocco MA
	Libya LY

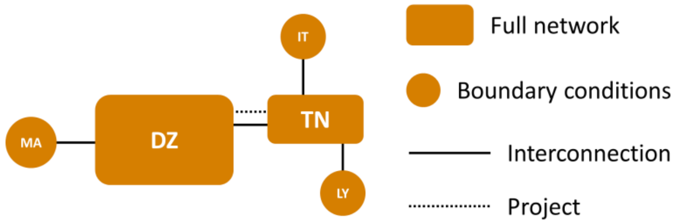

Table 1 – Participation of each of the systems involved in project DZTN

For this project, the Algerian and Tunisian systems have been considered as full represented by their transmission network models. Boundary systems, i.e. Morocco, Italy and Libya, 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)

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.

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 DZTN project

Connections between Algeria and Tunisia are well defined in both sides. For the interconnection between Italy and Tunisia, bus HAWARIA has been identified in the Tunisian networks.

Bus	Area (from)	Substation	Area (to)
BOUM111	Algeria DZ	Boussidi	Morocco MA
OUJM211	Algeria DZ	Oujda	Morocco MA
HAWARIA	Tunisia TN	Hawaria	Italy IT
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 DZTN 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 DZTN project.

PROJECT	Bus	Area	Subs.	Bus	Area	Subs.	LINK
DZTN	CHEFIA	Algeria DZ	Chefia	JENT112	Tunisia TN	Jendouba	HVDC

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

Project DZTN involves a second AC-OHL circuit for the 400 kV interconnection between Tunisia and Algeria. Buses in the Algerian side (CHEFIA) and the Tunisian side (JENT112) have been identified.

3 Snapshots definition and building process

For the project DZTN, a total number of five 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 DZTN project.

project DZTN PiT 1 - Power Balance [MW]

sys	PG	PD	Pexport	DZ	TN	IT	MA	LY
Algeria DZ	16163.1	16205.0	-41.9	0.0	958.1	0.0	-1000.0	0.0
Tunisia TN	2435.5	3423.0	-987.5	-958.1	0.0	-529.4	0.0	500.0

project DZTN PiT 2 - Power Balance [MW]

sys	PG	PD	Pexport	DZ	TN	IT	MA	LY
Algeria DZ	23452.2	23404.2	48.0	0.0	1000.0	0.0	-952.0	0.0
Tunisia TN	4890.1	6318.6	-1428.5	-1000.0	0.0	-600.0	0.0	171.5

project DZTN PiT 3 - Power Balance [MW]

sys	PG	PD	Pexport	DZ	TN	IT	MA	LY
Algeria DZ	31488.4	30906.6	581.7	0.0	591.9	0.0	-10.1	0.0
Tunisia TN	6731.3	7179.9	-448.5	-591.9	0.0	-356.7	0.0	500.0

project DZTN PiT 4 - Power Balance [MW]

sys	PG	PD	Pexport	DZ	TN	IT	MA	LY
Algeria DZ	29648.4	28294.9	1353.5	0.0	1000.0	0.0	353.5	0.0
Tunisia TN	5723.4	6445.7	-722.3	-1000.0	0.0	-222.3	0.0	500.0

project DZTN PiT 5 - Power Balance [MW]

sys	PG	PD	Pexport	DZ	TN	IT	MA	LY
Algeria DZ	36255.8	36255.8	0.0	0.0	1000.0	0.0	-1000.0	0.0
Tunisia TN	4456.1	5603.7	-1147.6	-1000.0	0.0	-600.0	0.0	452.4

Table 5 – Power balance for each of the PiTS defined in the DZTN 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 DZTN. 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 one value, i.e. rate A = rate B = rate C. For lines and transformers, rate A will be considered all snapshots. 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 been considered for Tunisia.

5 Assessment of reinforcements

No remarkable overloads associated to the new interconnection were identified in the Algerian system, thus no reinforcements were defined for Algeria. Tunisia has been the only system that has set reinforcements to be considered.

The energy interchange with Algeria through the existing and projected interconnection undergoes some overloads in the 220 kV network. To overcome this, the existing 220 kV interconnection between Algeria and Tunisia is opened, thus the energy tends to flow through the 400 kV subnetwork. To reinforce it, next new devices are considered:

- New 400 kV circuit Oueslatia - Mornaguia (140 km)
- Two (2) new 400 MVA, 220/400 kV transformers at Oueslatia substation

In addition, a reinforcement is needed to evacuate the power at Jendouba substation. Two different alternatives have been considered, 1) a new 400 kV circuit between Jendouba and Oueslatia substations, or 2) a new 400 kV circuit between Jendouba and Mornaguia substations. Both alternatives provide a new 400 kV corridor for the energy of the interconnection, and results obtained in the security analysis are quite similar, solving most of the overloads due to the new interconnection. Comparing them, first alternative (400 kV Jendouba - Oueslatia) seems to be a bit more effective, since the second alternative (400 kV Jendouba - Mornagui) is not capable of solving some of the problems in the N-1 situations, such as 220 kV Jendouba – Kef (PiT 4), or 200 kV B.M.Cher – Mornagui, Mnihla – Chotrana and Naassen - Mornagui (PiT 5).

Next figures show the maps of interconnections, both existing (dashed-yellow line) and planned (yellow line), and corresponding reinforcements (green line).

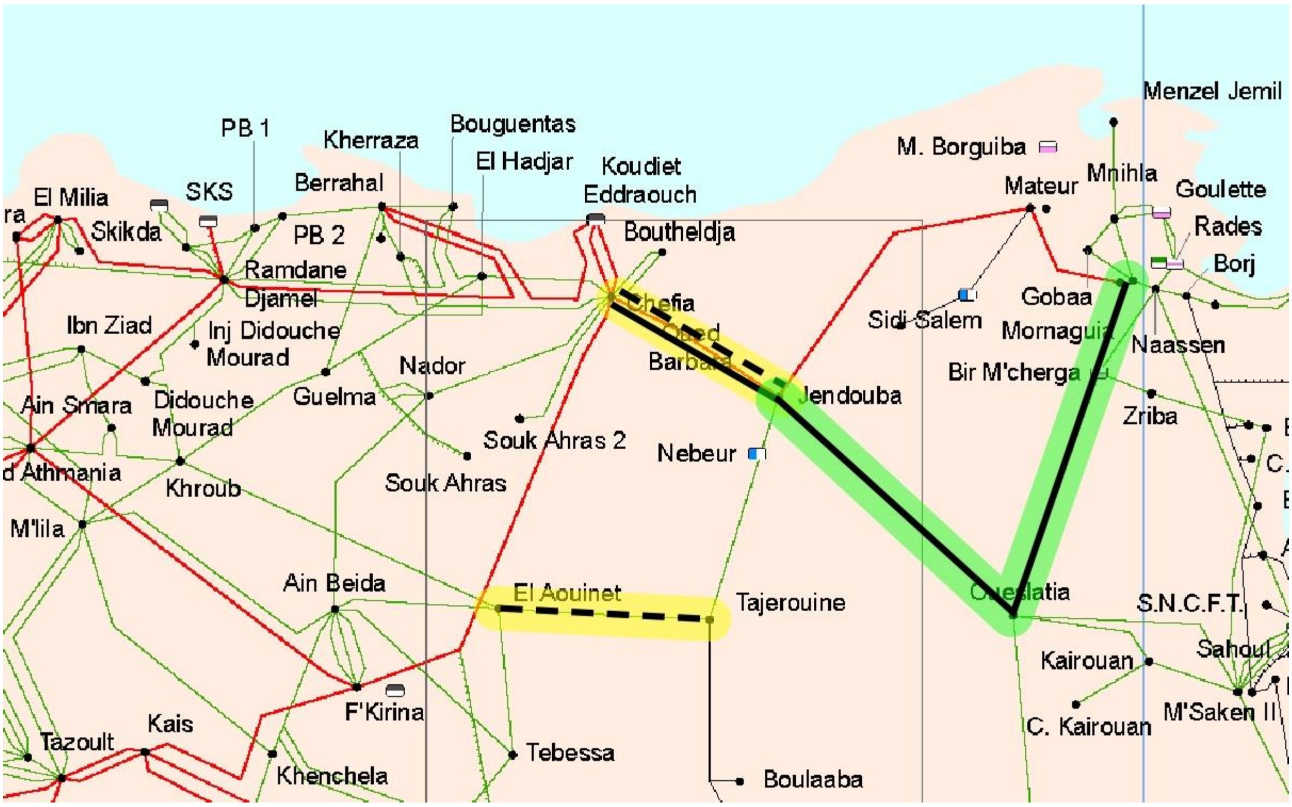

Figure 1 – Map of interconnections and reinforcements for project DZTN

6 Estimation of Active Power Losses

Internal losses in each country

To evaluate the performance of the new interconnection projects plus the associated internal 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 and Table 7 with the results for the Tunisian system.

	Power losses [MW]		
PiT	Without proj&reinf	With proj&reinf	Difference (W-WO)
1	455.0	546.5	91.5
2	354.5	370.0	15.5
3	422.2	442.8	20.5
4	411.7	460.6	48.9
5	632.9	605.1	-27.8

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	106.5	71.0	-35.5
2	66.4	76.4	10.1
3	84.2	80.0	-4.2
4	66.1	101.2	35.1
5	33.0	67.8	34.8

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

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 AC 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:

link	r_l [pu]	NTC_{new} [MW]	NTC_{total} [MW]
DZ-TN	0.0015	700	1000

Table 8 – Parameters for the losses estimation in the DZTN interconnections

The following table shows the annual losses estimate on the interconnection project for each scenario:

Scenario	Annual Losses (GWh)
S1	10.6
S2	9.7
S3	8.9
S4	9.9

Table 9 – Annual losses estimate for the DZTN new interconnection

7 Estimation of Investment Cost

The new AC link between Algeria and Tunisia consists of 82 km of AC OHL. Using 0.3 M€/km for the average cost of the AC cables including installation, the estimate for the cable cost is 24 M€. The cost of the end substations is estimated to be 3.3 M€, for both, including one AIS bay. Finally, the total investment cost in the new AC interconnection is 27 M€.

The following tables provide an estimate for the investment cost for the internal reinforcements, and the Cost Benefit Analysis (CBA) carried out based on the results of EES and TC1 activities of the Mediterranean Project. It should be noted that this is an estimation of the cost based on the best practices in the region.

P7 - DZTN - Investment Cost									
New Interconnections									
Description	**Type**	**Countries Involved**	**Length/number**		**Total Investment Cost**	**GTC Contribution**	**Location**	**Status**
			OHL [km]	**Cable [km]**	**M€**	**MW**		
400 kV OHL Cheffia (DZ) - Jendouba (TN)	AC-400 kV OHL	DZ	40		12	700	NEDZ - NW TN	Long-term
	One (01) AIS baie 400 kV OHL	DZ	1		1.3			
	AC-400 kV OHL	TN	42		12			
	One (01) GIS baie 400 kV OHL	TN	1		2			
Total Cost of New Interconnections (M€ / %total)					**27**	**18%**		
Internal Reinforcements								
Description	**Type**	**Countries Involved**	**Length/number**		**Total Investment Cost**	**Capacity**	**Location**	**Status**
			OHL [km]	**Cable [km]**	**M€**	**MW / MVA**		
OHL 400 kV		TN	140		56		Mornaguia-Oueslatia	
OHL 400 kV		TN	150		60		Jendouba-Oueslatia	
Bays for OHL 400 kV		TN	4		6		Mornaguia, Jendouba, Oueslatia	
AutoTransformer 400/225 KV-400 MVA		TN	1		3		Oueslatia	
Bay AutoTransformer 400 kV		TN	1		2		Oueslatia	
Bay AutoTransformer 225 kV		TN	1		1		Oueslatia	
Total Cost of Internal Reinforcements (M€ / %total)					**128**	**82%**		
Total Project Investment Cost					**155**			

Table 10 – Investment cost of the project DZTN

Assessment results for the Cluster P7 - DZTN														
non scenario specific	GTC increase direction 1 (MW)		700											
	GTC increase direction 2 (MW)		700											
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	2000	700	1300	2000	700	1300	2000	700	1300	2000	700
		TN	800	1500	700	800	1500	700	800	1500	700	800	1500	700
Interconnection Rate (%)*		DZ	2,6%	4,1%	1,4%	2,5%	3,8%	1,3%	1,9%	2,9%	1,0%	2,0%	3,1%	1,1%
		TN	8,8%	16,6%	7,7%	8,4%	15,7%	7,3%	7,7%	14,4%	6,7%	6,2%	11,6%	5,4%
Benefit Indicators	B1-SEW	(M€/y)	19			26			12			22		
	B2-RES	(GWh/y)	0			0			0			40		
	B3-CO_2	(kT/y)	1200			550			800			900		
	B4 - Losses	(M€/y)	15,5			16,6			5,0			-9,6		
		(GWh/y)	233			232			70			-125		
	B5a-SoS Adequacy	(MWh/y)	0			0			20			20		
	B5b-SoS System Stability													
Residual Impact Indicators	S1- Environmental Impact													
	S2-Social Impact													
	S3-Other Impact													
Costs	C1-Estimated Costs	(M€)	155											

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

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/Year] =	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	
neutral impact	
positive impact	
Not Available/Not Available	
monetized	

Table 11 – Results of the Cost Benefit Analysis for the DZTN 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

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