Project #6 – EGYPT – TURKEY

Description

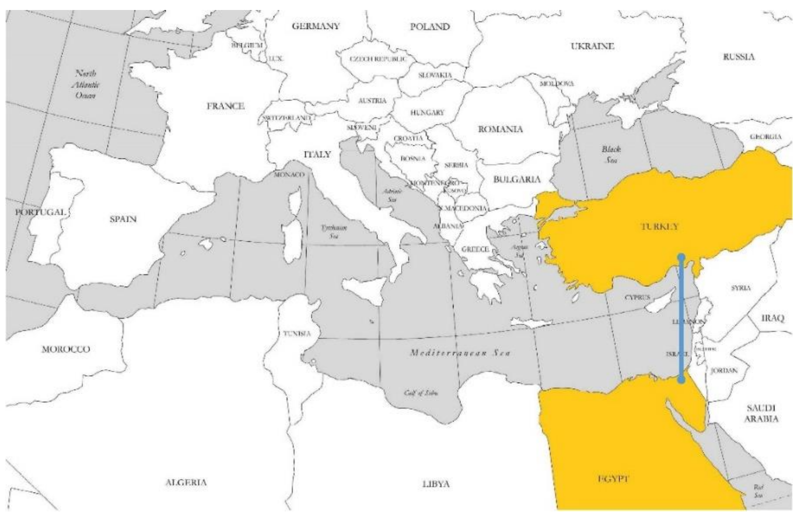
At present there are no interconnections between Egypt and Turkey.

The Egyptian grid is currently interconnected with the grids of Libya, Jordan and Sudan. More specifically:

- Egypt and Libya are electrically interconnected since 1998 via a 220 kV double circuit line between Saloum and Tobruk, enabling a Net Transfer Capacity (NTC) of 180 MW on both directions.
- Egypt and Jordan are electrically interconnected since 1998 via a 13km 400kV submarine cable with an exchange capacity of 550MW across the Gulf of Aqaba to Taba. NTC between the two countries is limited at 550 MW on both directions.
- Egypt and Sudan are electrically interconnected since 2020 via a 167 Km 220 KV line with NTC between the two countries is expected to reach 300 MW by 2030
- A new HVDC interconnection between Egypt-Saudi Arabia is currently under way and NTC between the two countriesis expected to be 3000 MW before 2030.

The Turkish grid is currently interconnected with the grids of Greece, Bulgaria, Syria, Iraq, Iran, Nakhchivan (Azerbaijan) and Georgia. More specifically:

- Through the interconnections to Greece and Bulgaria, the Turkish grid is synchronously interconnected to Continental Europe Synchronous Area (CESA). Due to some limiting factors not related to the grid expansion, total NTC values are limited to 650 MW on CESA to Turkey direction and 500 MW on the opposite direction. The second interconnection between Greece and Bulgaria and the related strengthening of the 400 KV South-East Bulgaria which is under way, are expected to contribute to the increase of NTC to 1350 MW on CESA to Turkey direction and to 1250 MW on the opposite direction.
- The Turkish and Syrian grids are linked with one 400 kV AC overhead interconnection line, connected to Haleppo SS at the Syrian side and to Birecik HPP Substation at the Turkish side. Before TEIAS synchronously connected to ENTSO-E network, the interconnection had been used to connect 2 units of Birecik HPP in Turkey to feed the Syrian network (unit direction method). After joining the ENTSO-E, TEIAS had to switch off the line. A Back to Back (B2B) converter substation is planned to be constructed next to Birecik HPP Substation on Turkish side and was already in the investment plan of TEIAS before the war in Syria. TEIAS postponed this investment until the stabilization of the situation in Syria. After the completion of the converter station the two grids will be fully connected asynchronously to each other B2B.
- The Turkish grid is also connected to Georgia B2B asynchronously and through isolated region method with the grids of Iraq and Iran. The construction of B2B station in Van (Turkey) is ongoing and after commissioning of the B2B station in Van, Turkey and Iran grids will be connected asynchronously.



Egypt and Turkey are part of the 8 countries interconnection, also including Syria, Lebanon, Jordan, Iraq, Palestine, and Libya.

The project consists of a new interconnection between Turkey and Egypt, to be realized through a submarine 3000 MW HVDC link. It is worth noting that this project is not included in the respective Egyptian National Plan. This document presents the explorative study of the project performed by MedTSO under the umbrella of MPII.

Project Description Table							
Description	***Substation (from)***	***Substation (to)***	***GTC contribution (MW)***	***Total Route length (km)***	***Present status***	***Expected commissioning date***	***Evolution***
New interconnection between Turkey and Egypt (HVDC)	Turkey (TR)	Egypt (EG)	3000	800			

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Project Merits

The major merits of the project relevant to the Mediterranean electricity system are listed below:

	PROJECT MERITS	ASSOCIATED SYSTEM NEEDS	PROJECT 6
Market	Reduce high price differentials between different market nodes and/or countries	Power studies with a 2030 time horizon can highlight significant differences in average marginal prices between countries, groups of countries or bidding zones. These differences are generally the consequence of structural differences in the composition of production fleets. The increase in the exchange capacity between these zones allows an economic optimization of the use of the generation plants and will be accompanied by electricity flow massively oriented in one direction, from the lower price country to the higher prices country, thus reducing the price differential.	X
Dispatch, Adequacy and Security of Supply	Positively contribute to the integration of renewables	Infrastructure to mitigate RES curtailment and to improve accommodation of flows resulting from RES geographic spreading.	X
	Contribute to solving issues related to adequacy and security of supply	Infrastructure that presents a benefit for the security of supply or system adequacy, in general by allowing additional importation at peak hours, in countries and areas presenting current of future risk of deficiencies	X
Operation	Fully or partially contribute to resolving the isolation of countries in terms of power system connectivity or to meeting specific interconnection targets	Infrastructure to connect island systems, or to improve exchange capacity of countries showing low level of connectivity, or to contribute to meeting specific interconnection capacity targets	
	Introduce additional System Restoration mechanisms	Infrastructure that could provide capability for Black Start & Islanding Operation thus decreasing the need for generation units with such capabilities	
	Improve system flexibility and stability	Infrastructure to improve system flexibility and stability, by increasing sharing possibilities, namely in countries were expected changes in the generation fleet may raise concerns in those specific issues. Decreasing levels of dispatchable generation can be compensated by infrastructure and/or market design to provide balancing flexibility at cross-border level (international pooling/sharing of reserves, coordinated development of reserve capacity). The large increase in the penetration of asynchronous renewable generation is leading to Higher Rate of Change of Frequency (RoCoF) on the system, creating transient stability issues and causing voltage dips. This can be compensated through infrastructure designed to contain frequency during system events.	
	Increase system voltage stability	Reactive power controllability of converters can be used to increase system voltage stability	
	Enable cross-border flows to overcome internal grid congestions	Infrastructure to facilitate future scenarios and enable cross border flows, accommodating new power flow patterns, overcoming internal grid congestions	
	Mitigate loop flows in bordering systems	Infrastructure to mitigate the loop flows occurrence in the borders between Mediterranean countries, contributing to the improvement of exchange capacity.	
	Contribute to the flexibility of the power systems through the control of power flows	Contribution to flexibility of power system operation by controlling power flows and optimizing usage of existing infrastructure	
Physical infrastructure	Refurbishment of obsolete infrastructure	Infrastructure to contribute to the refurbishment of obsolete part of grid initially designed in different context	

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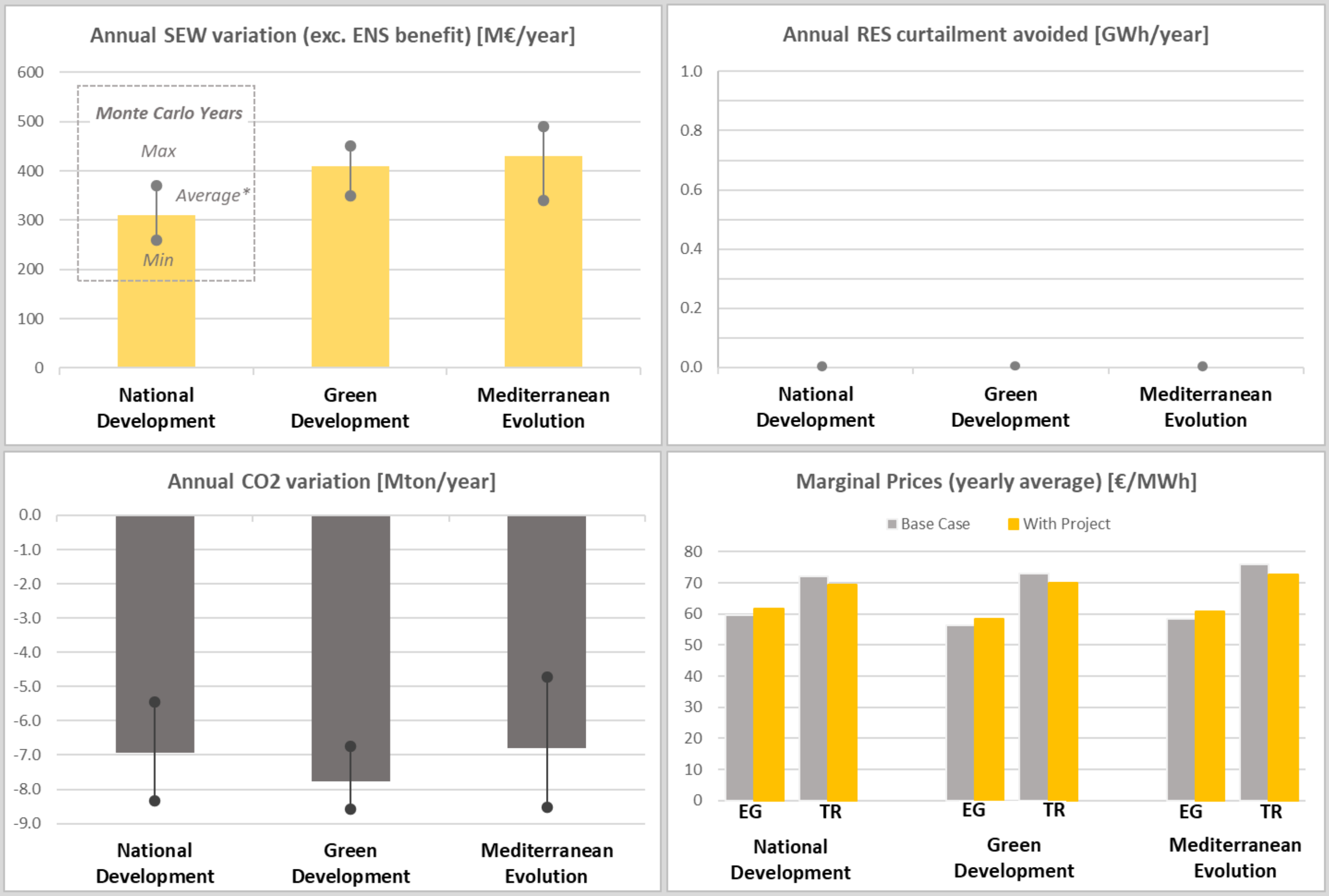
Project assessment analysis

CBA Indicators

Project 6 yields a positive impact in the values of the CBA indicators across the 3 simulated scenarios. A significant increase of the SEW is reported as a result of the use of the new interconnection, while there is also a small decrease in RES curtailment with the greater expected benefit being noticed in the Mediterranean Evolution scenario and a consistent decrease in overall CO_2 emissions.



* Average of the outputs calculated for all the Monte Carlo Years

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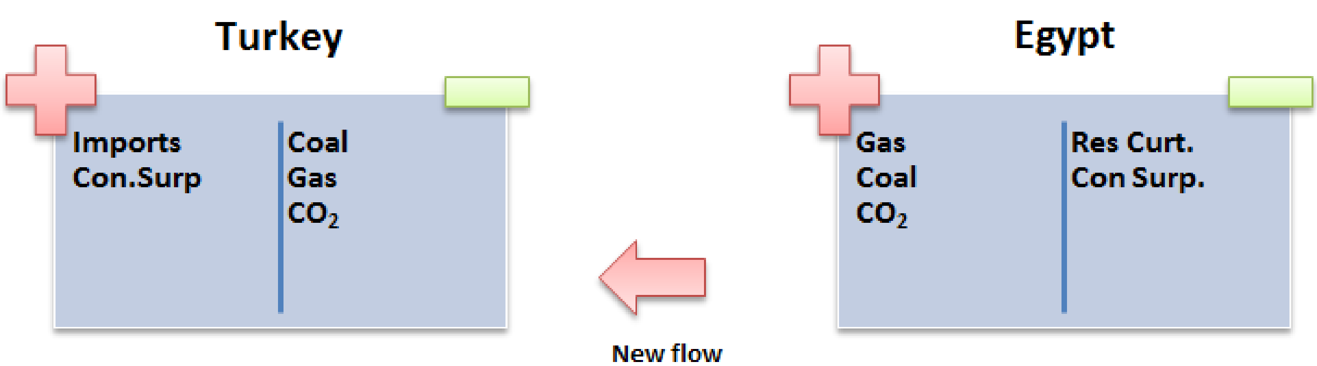
Project assessment analysis

Market Studies

Project 6 drives an overall replacement of coal-based generation by gas-based generation. Furthermore, the introduction of the new interconnection leads to significant imports to Turkey from Egypt, resulting in the substitution of local coal and gas based generation across the 3 simulated scenarios by gas generation from Egypt (and coal generation from Egypt in a much lesser extent). More specifically:

- **Generation mix:**
  - **EG:** increase in local gas-based generation in all scenarios (and also in coal-based generation in a much smaller degree)
  - **TR:** reduction in local coal and gas-based generation in all scenarios

- **Country balance and cross-country power flows:** the flows observed in the new interconnection are mostly from Egypt to Turkey, with an expected significant number of hours of saturation of the flow in this direction. A noticeable decrease in exchanges of Egypt with neighboring countries (Jordan and Libya) and Turkey with neighboring countries (Syria, Greece and Bulgaria) is also observed. The increase in the exchange capacity has a significant impact on both countries and a smaller impact on neighboring countries.



Project #6 – EGYPT – TURKEY

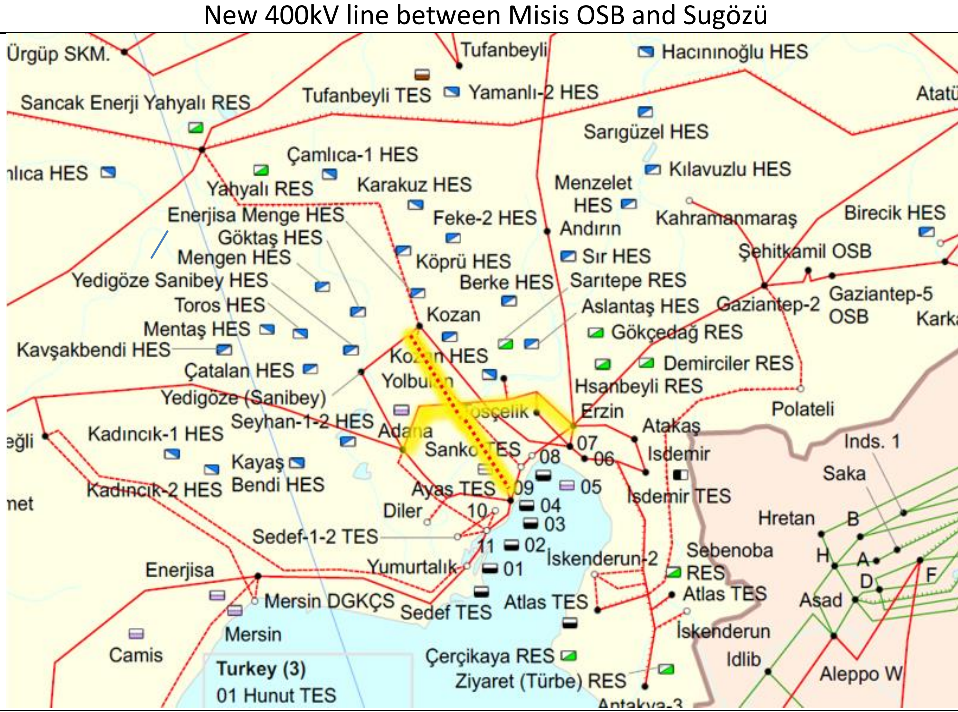
Project assessment analysis

This project consists in a new HVDC link between Egypt and Turkey, to be realized through a submarine 3000MW cable with a length of 800km.

For the analysis, the Turkish system has been fully represented by its network model. On the other hand, the system of Egypt was represented as an external bus since the full model was not available. The same bus bar representation is applied for the rest of the border countries: Greece, Bulgaria, Syria, Israel, Iraq and Georgia.

For this project, 3 scenarios (S1, S2 and S3) were distinguished and total number of 9 Points in Time have been defined, 3 Points in Time per scenario. The N and N-1 static analysis identified the following reinforcements for the system of Turkey, while for the third countries that are included in the project no internal reinforcements were suggested.

Scenario 1, 2, 3
Description (Turkey)
Upgrade the existing 400kV line between Adana and Bastug
Upgrade the existing 400kV line between Tosçelik and Bastug
Upgrade the existing 400kV line between Erzin and Tosçelik
New 400kV line between Kozan and Misis OSB
New 400kV line between Misis OSB and Sugözü



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Project assessment analysis

The overall investment cost ranges between 2582M€ and 3112M€, 1.2%-1% of which represents investment for internal reinforcements in Turkey. The internal cost is estimated to be 33M€. The more detailed breakdown of the cost is presented below.

Investment cost-Interconnection						
Line	**Cost [M€]***					
	LCC bip		**LCC bip**		**VSC bip**	**VSC 2-bip**
Voltage level [kV]	**600**	**800**	**600**	**800**	**600**	**600**
DC OHTL	30	-	30	-	-	30
DC CABLE	1960	-	2090	-	-	2090
AC/DC converter station Egypt	230	-	370	-	-	480
AC/DC converter station Turkey	230	-	370	-	-	480
TOTAL	**2450**	**-**	**2860**	**-**	**-**	**3080**

Investment cost –internal reinforcements	
Upgraded lines	**Cost [M€]***
400 kV OHL Adana - Bastug	10
400 kV OHL Tosçelik - Bastug	1
400 kV OHL Erzin - Tosçelik	2
New Lines	
400kV OHL Kozan-Misis OSB	10
Line bays	1
400kV OHL Misis OSB-Sugözü	7
Line bays	1
TOTAL	**32**

*Rounded values

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Project cost benefit analysis results

Assessment results for the Project #6: Egypt - Turkey											
GTC increase direction 1 (MW)			3000								
GTC increase direction 2 (MW)			3000								
Scenario Specific			MedTSO Scenario								
			1 - National Development (ND)			2 - Green Development (GD)			3 - Mediterranean Evolution (ME)		
			Reference Scenario	With new project	Delta	Reference Scenario	With new project	Delta	Reference Scenario	With new project	Delta
GTC/NTC - Import		EG	3730	6730	3000	3730	6730	3000	3730	6730	3000
		TR	3560	6560	3000	3560	6560	3000	3560	6560	3000
GTC/NTC - Export		EG	3730	6730	3000	3730	6730	3000	3730	6730	3000
		TR	3080	6080	3000	3080	6080	3000	3080	6080	3000
Interconnection Rate - Import/Export (%) [1]		EG	4.2% / 4.2%	7.7% / 7.7%	3.4%	4.0% / 4.0%	7.2% / 7.2%	3.2%	3.5% / 3.5%	6.3% / 6.3%	2.8%
		TR	2.9% / 2.5%	5.4% / 5.0%	2.5%	2.8% / 2.4%	5.1% / 4.8%	2.3%	2.5% / 2.2%	4.6% / 4.3%	2.1%
Scenario Specific			MedTSO Scenario								
			1 - National Development (ND)			2 - Green Development (GD)			3 - Mediterranean Evolution (ME)		
Based on Monte Carlo Years			Average	Min	Max	Average	Min	Max	Average	Min	Max
Benefit Indicators	B1 - SEW[2]	(M€/y)	310	260	370	410	350	450	430	340	490
	B2 - RES Integration[3]	(GWh/y)	0	0	0	0	0	0	0	0	0
	B3 - CO_2	(Mton/y)	-6.9	-8.3	-5.4	-7.8	-8.6	-6.8	-6.8	-8.5	-4.7
	B4 - Losses[2]	(M€/y)	40			50			40		
		(GWh/y)	840			870			930		
	B5a - SoS Adequacy[4]	(GWh/y)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		(M€/y)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	B5b - SoS System Stability										
Residual Impact Indicators	S1 - Environmental Impact										
	S2 - Social Impact										
	S3 - Other Impact										
Costs	C1 - Estimated Cost[5]	(M€)	2830								

[1] considering the GTC/NTC for 2030 and the Installed generation for 2030

[2] considering adequate rounding of values (to the tens)

[3] ignoring low values and negative values of RES integration (average values below 50GWh lead to setting average, min and max equal to zero) and considering adequate rounding of values (to the tens)

[4] ignoring low values (average values below 0.1 GWh/y lead to setting average, min and max equal to zero)

[5] based on the average value of the different technology options considered in the analysis (if applicable)

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 [Mton/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 [GWh/Year] and [M€/y]= Positive when a project reduces the risk of lack of supply

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