Project #8 – EGYPT – JORDAN

Description

The Egyptian grid is currently interconnected with the grids of Libya, Jordan and Sudan. A new HVDC interconnection between Egypt-Saudi Arabia is currently under way and NTC between the two countries is expected to be 3000 MW before 2030. This new interconnection is part of the interconnected 400 kV electric grid which is planned in the area, linking the GCC Interconnection Authority Grid (connecting the grids of the six GCC countries at 400 kV) with the systems of Jordan and Egypt, with the aim to enhance system reliability, improve quality of supply and pave the way for the creation of an electrical energy market in the Arab region.

Jordan and Egypt are electrically interconnected since 1998 via a 13 km 400 kV, AC submarine cable (3 + 1 spare) submersed at a depth of 850 m across Taba to the Gulf of Aqaba with an exchange capability of 550 MW. Project 8 consists of a second interconnection between Jordan and Egypt to be realized through a 13 km 400 kV, AC submarine cable. It is expected to increase the current transfer capacity between the two countries to reach 1100 MW, aiming to mitigate possible overloads in the path of the interconnection.

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

Project Description Table							
Description	***Substation (from)***	***Substation (to)***	***GTC contribution (MW)***	***Total Route length (km)***	***Present status***	***Expected commissioning date***	***Evolution***
New interconnection between Egypt and Jordan (400kV AC submarine cable)	Jordan (JO)	Egypt (EY)	550	13	Long-term project		

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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 8
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.	
	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.	X
	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	X
	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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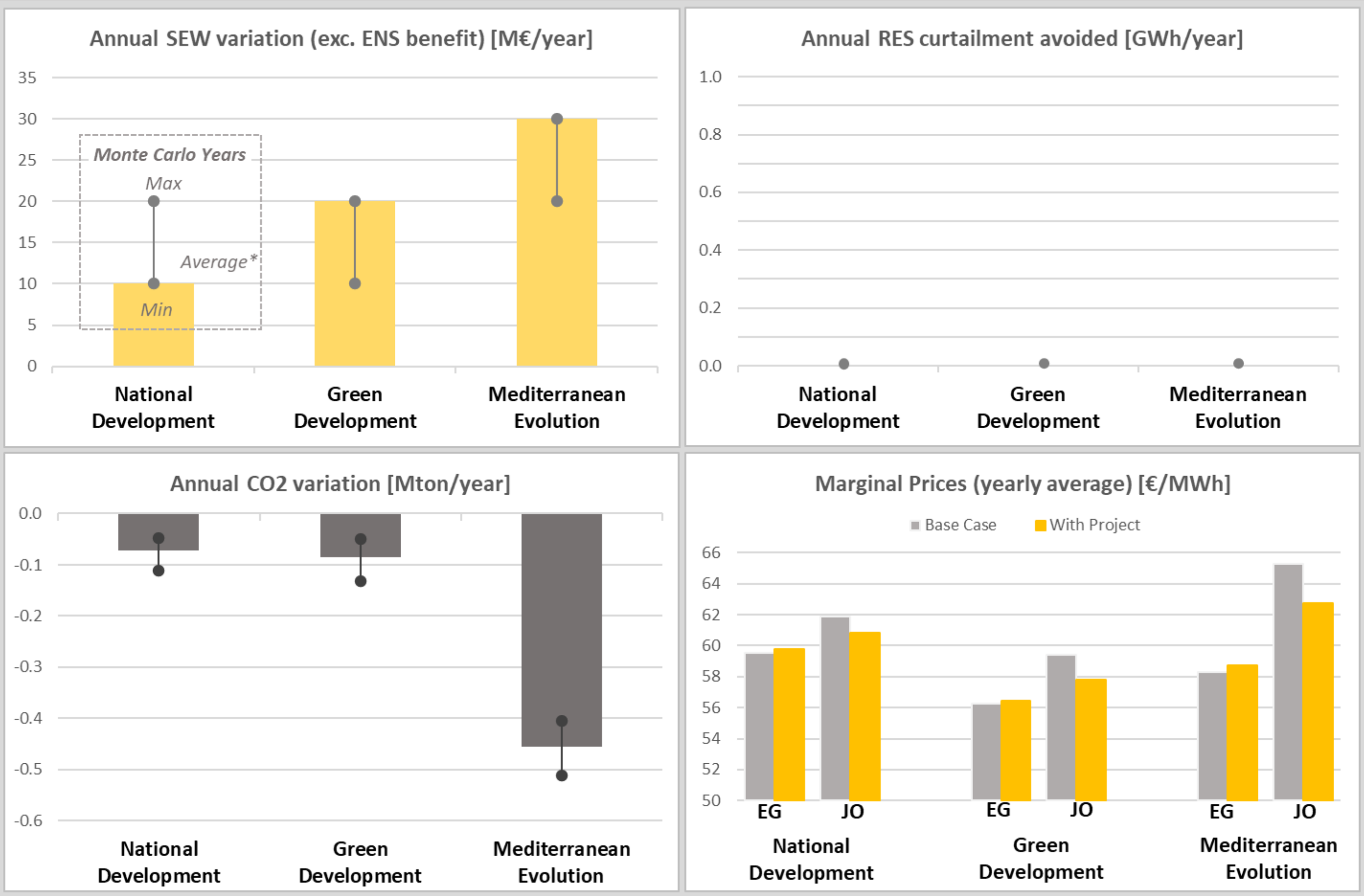
Project assessment analysis

CBA Indicators

Project 8 yields a consistent positive impact in the expected values of the SEW and a minor positive impact on CO_2 emissions across the 3 simulated scenarios, with the greater expected benefit being noticed for both indicators in the Mediterranean Evolution scenario. In what concerns the impact of the project on RES curtailment the analysis does not produce stable results which could be further evaluated (wide range of maximum and minimum values and negligible average value for the MC Years).



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

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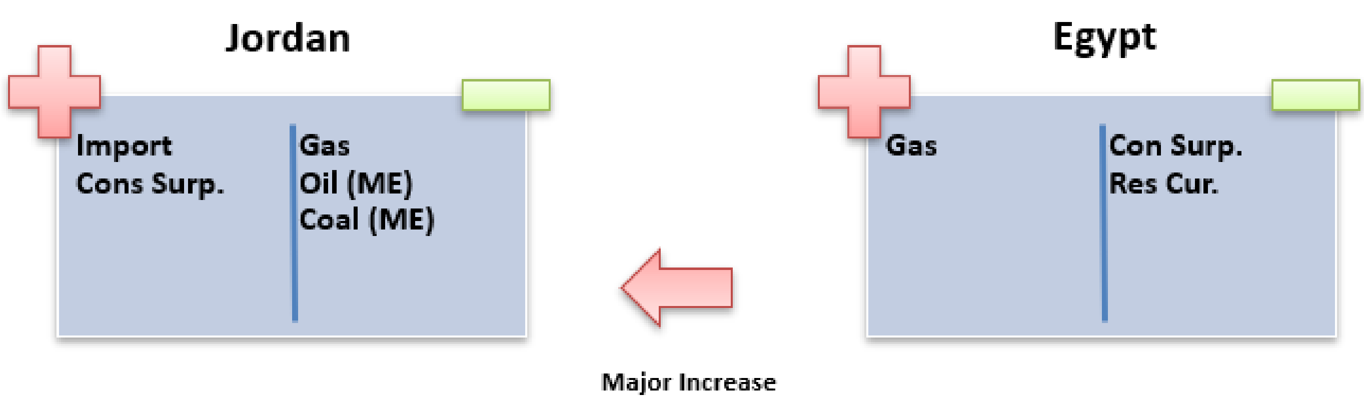
Project assessment analysis

Market Studies

Project 8 drives a significant increase in the exports from Egypt to Jordan resulting in the substitution of gas-based generation in Jordan with gas-based generation in Egypt across the 3 simulated scenarios. More specifically:

- **Generation mix:**
  - **EG:** increase in local gas-based generation in all scenarios
  - **JO:** reduction in local gas-based in all scenarios. Smaller reduction in oil and coal-based generation observed in the Mediterranean Evolution Scenario

- **Country balance and cross-country power flows:** due to the increase in the NTC between Egypt and Jordan with the new interconnection, there is a significant increase in the exports from Egypt to Jordan in all scenarios. The impact on neighbouring countries is negligible.



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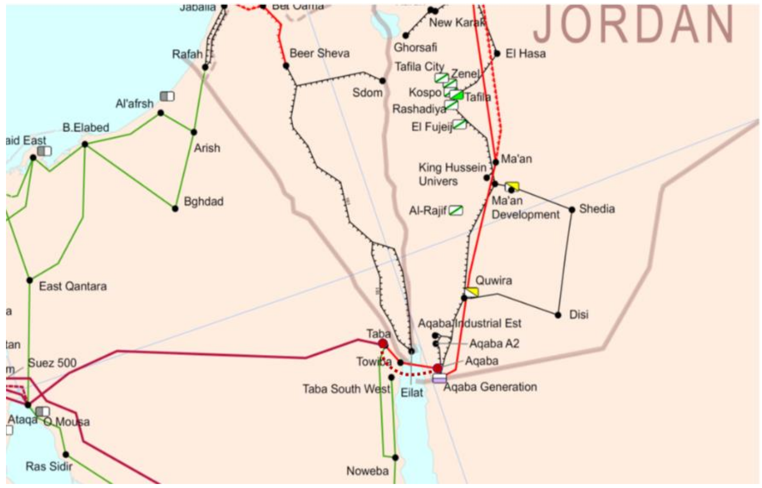
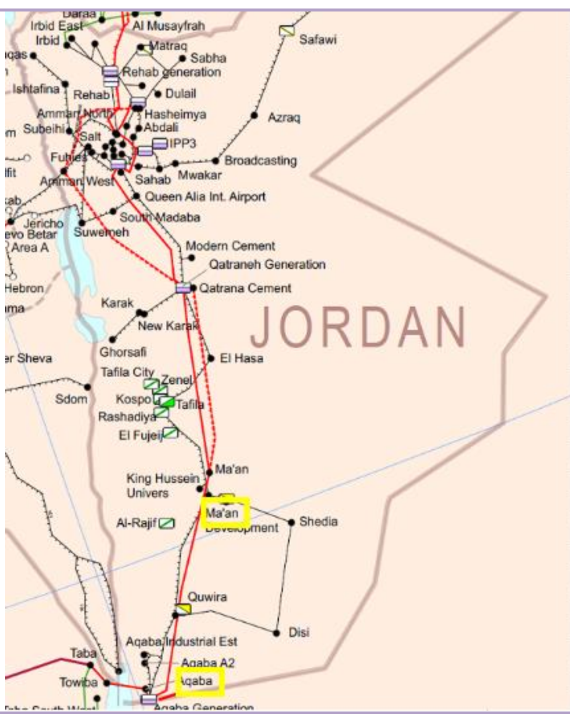
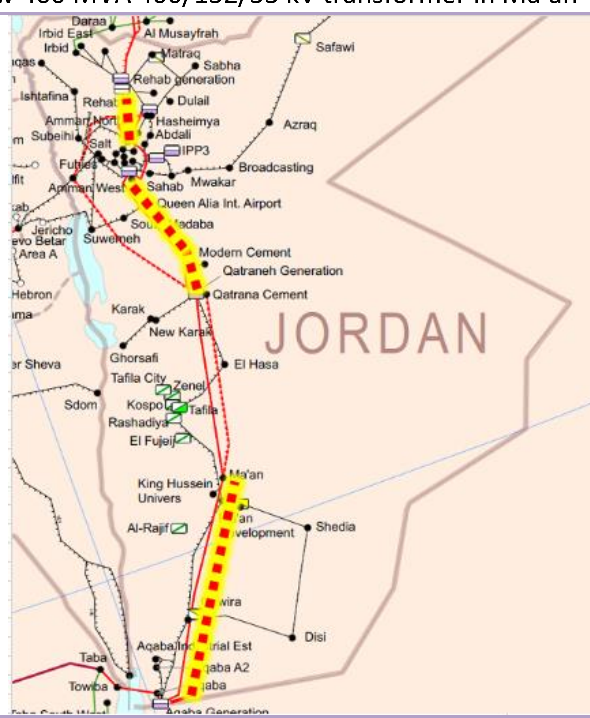
Project assessment analysis

The project consists in a new AC 400kV OHL between Jordan and Egypt. The new 13km link between Egypt and Jordan will increase the capacity for an additional 550MW. The system of Jordan is represented with its full network model. However the model for the system of Egypt was not available. Therefore, the system of Egypt is represented as an external bus.

For this project 3 different scenarios were distinguished and a total number of 9 Points in Time were defined. The security analysis performed for the transmission level identified the reinforcements for the system of Jordan, given in the table below. For the third countries included in this project no internal reinforcements were suggested.



Scenario 1	Scenario 2, 3
Description (Jordan)	**Description (Jordan)**
New 240 MVA 400/132/33 kV transformer in Aqaba	Doubling the existing 400kV double circuit between Aqaba and Ma'an
New 400 MVA 400/132/33 kV transformer in Ma'an	New line between Amman North and Samra 400 kV
	New line between Amman South and Qatrana 400 kV
	New 240 MVA 400/132/33 kV transformer in Aqaba
	New 400 MVA 400/132/33 kV transformer in Ma'an
	

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Project assessment analysis

The overall investment cost is expected to be 146.2M€, 78% of which represent investment for internal reinforcements in Jordan. The system of Egypt has not been evaluated, hence no internal costs are related with this country. The more detailed breakdown of the cost is presented below.

Investment cost-Interconnection	
Line	***Cost [M€]****
AC cable Egypt	10
AC cable Jordan	10
AC OHTL Egypt	5
AC OHTL Jordan	3
1 bay Egypt	2
1 bay Jordan	1
line reactor Egypt	1
line reactor Jordan	0
TOTAL	**32**

Investment cost –internal reinforcements*	
New Lines	***Cost [M€]****
400kV OHL Aqaba - Ma'an (JO)	50
line bays	3
Reactive power compensation	1
400kV OHL Amman North - Samra (JO)	10
line bays	3
400kV OHL Amman South - Qatrana (JO)	30
line bays	3
Reactive power compensation	1
New Transformers	
New 240 MVA 400/132/33 kV transformer in Aqaba	3
Transformer bay 400 kV	1
Transformer bay 132 kV	0.5
Transformer bay 33 kV	0.1
Reactive power compensation 33 kV	1
New 400 MVA 400/132/33 kV transformer in Ma'an	5
Transformer bay 400 kV	1
Transformer bay 132 kV	0.5
Transformer bay 33 kV	0.1
Reactive power compensation 33 kV	1
TOTAL	**114.2**

*the solution with the highest costs of reinforcements is here shown

**Rounded values

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Project cost benefit analysis results

Assessment results for the Project #8: Egypt-Jordan											
GTC increase direction 1 (MW)			550								
GTC increase direction 2 (MW)			550								
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	4280	550	3730	4280	550	3730	4280	550
		JO	2350	2900	550	2350	2900	550	2350	2900	550
GTC/NTC - Export		EG	3730	4280	550	3730	4280	550	3730	4280	550
		JO	2550	3100	550	2550	3100	550	2550	3100	550
Interconnection Rate - Import/Export (%) [1]		EG	4.2% / 4.2%	4.9% / 4.9%	0.6%	4.0% / 4.0%	4.6% / 4.6%	0.6%	3.5% / 3.5%	4.0% / 4.0%	0.5%
		JO	29.0% / 31.5%	35.8% / 38.3%	6.8%	25.1% / 27.2%	31.0% / 33.1%	5.9%	22.7% / 24.6%	28.0% / 29.9%	5.3%
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)	10	10	20	20	10	20	30	20	30
	B2 - RES Integration[3]	(GWh/y)	0	0	0	0	0	0	0	0	0
	B3 - CO_2	(Mton/y)	-0.1	-0.1	0.0	-0.1	-0.1	-0.1	-0.5	-0.5	-0.4
	B4 - Losses[2]	(M€/y)	0			-20			-10		
		(GWh/y)	-60			-230			0		
	B5a - SoS Adequacy[4]	(GWh/y)	0.0	0.0	0.0	0.0	0.0	0.0	0.2	2.6	0.0
		(M€/y)	0.0	0.0	0.0	0.0	0.0	0.0	0.6	7.9	0.0
	B5b - SoS System Stability										
Residual Impact Indicators	S1 - Environmental Impact										
	S2 - Social Impact										
	S3 - Other Impact										
Costs	C1 - Estimated Cost[5]	(M€)	150								

[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	
neutral impact	
positive impact	
Not Available/Not Applicable	
monetized	