Project #11 – GREECE – BULGARIA - TURKEY

Description

In 2010, the Turkish power system was synchronized to Continental Europe Synchronous Area (CESA), with Greece and Bulgaria being part of the CESA to Turkey transmission corridor. At present there is one interconnection between Greece and Bulgaria, one between Greece and Turkey and two between Bulgaria and Turkey, with NTC values currently 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.

Currently Greece is strongly interconnected with 1 DC and 6 AC interconnections: besides the interconnections with Turkey and Bulgaria, Greece is interconnected with N. Macedonia, Albania and Italy. The Turkish grid, besides the interconnections with Greece and Bulgaria, is currently interconnected with the grids of Syria, Iraq, Iran and Georgia.

The project consists in two new interconnections: one between Greece and Turkey and one between Bulgaria and Turkey to be realized through AC overhead lines and is promoted by IPTO, TEIAS and ESO. This document presents the explorative study of the project performed by MedTSO under the umbrella of MPII.

The realization of the project is aiming to further increase the interconnection capacity between Turkey and the CESA of about 1000MW.

Project Description Table							
Description	***Substation (from)***	***Substation (to)***	***GTC contribution (MW)***	***Total Route length (km)***	***Present status***	***Expected commissioning date***	***Evolution***
New interconnection between Greece and Turkey (AC)	N. Santa (GR)	Babaeski (TR)	500	130	Long-term project	Project under consideration	
New interconnection between Bulgaria and Turkey (AC)	Maritsa Iztok (BG)	Vize (TR)	500	190	Long-term project	Project under consideration	

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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 11
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	
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	X
	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	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.	X
	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	X
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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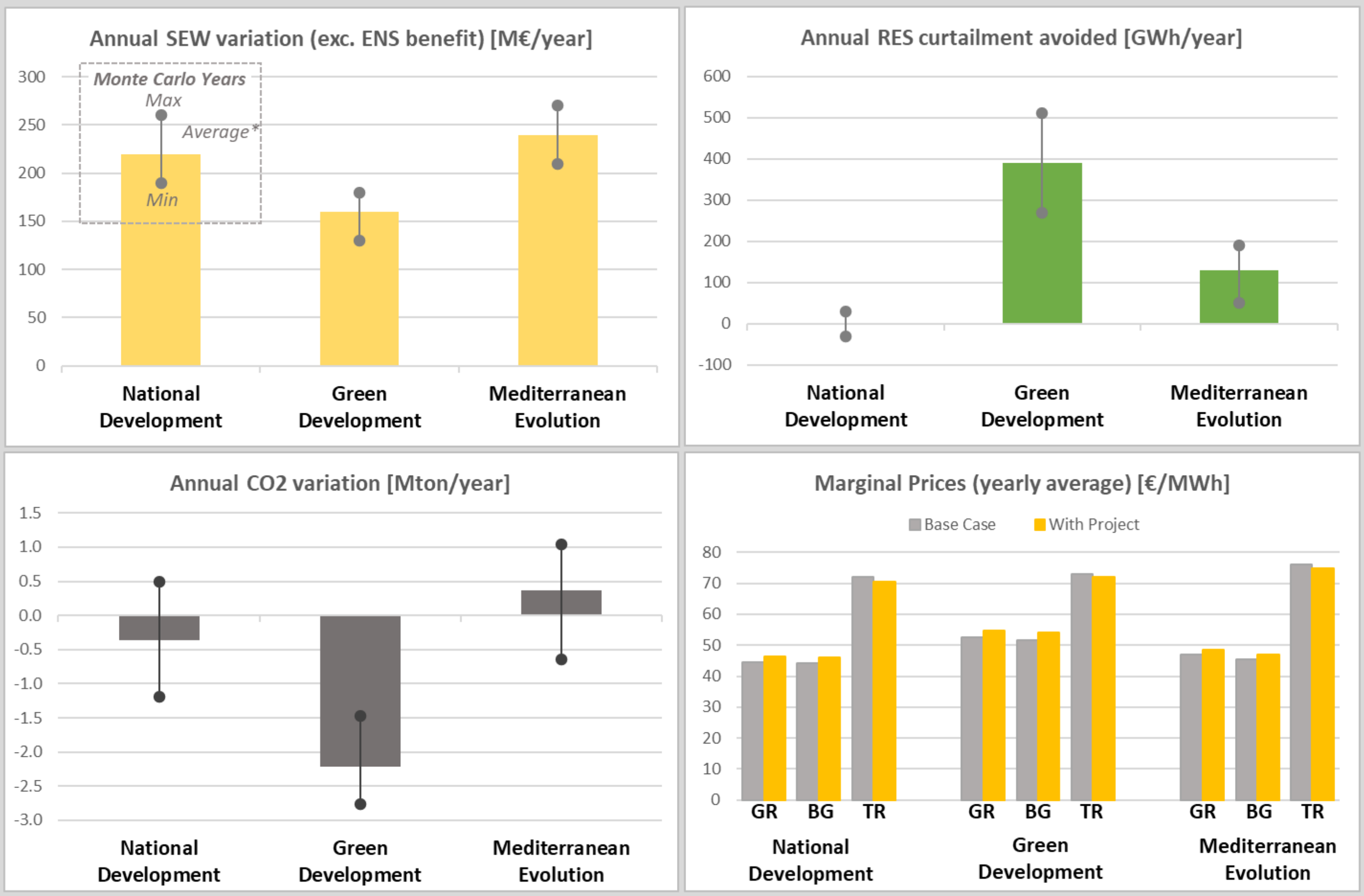
Project assessment analysis

CBA Indicators

Project 11 yields a positive impact in the values of the CBA indicators across the 3 simulated scenarios. The increase of the SEW as a result of the efficient use of the interconnections is considerable. Additionally, a significant decrease in RES curtailment is reported, with the greater expected benefit being noticed in the Green Development scenario. The impact of the project in the overall CO_2 emissions is scenario-dependent and rather negligible, with the greater expected benefit being noticed in the Green Development scenario.



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

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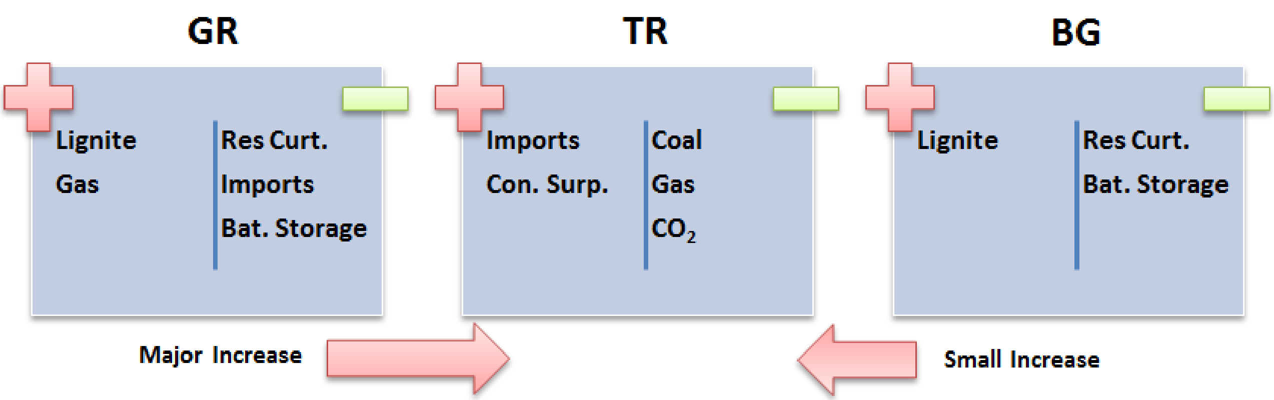
Project assessment analysis

Market Studies

Project 11 results in the substitution of coal by lignite, gas based and RES generation, enhanced by the efficient use of interconnections in the CESA to Turkey direction. More specifically:

- **Generation mix:**
  - **GR:** increase in lignite and gas based generation in all scenarios and decrease in RES curtailment and use of battery storage in scenarios Green Development and Mediterranean Evolution
  - **TR:** substitution of coal and gas based generation by lignite and gas based generation imported from Greece and Bulgaria, with a consequent decrease of CO_2 emissions, reported across the 3 simulated scenarios.
  - **BG:** increase in lignite based generation on the 3 simulated scenarios and decrease in RES curtailment and use of battery storage in scenarios Green Development and Mediterranean Evolution.

- **Country balance and cross-country power flows:** there is a significant increase in the exchanges from Greece and Bulgaria to Turkey, with saturation of the flow observed in this direction almost throughout the whole year, showing an expected full usage following the implementation of the project. This trend is common in the 3 simulated scenarios.



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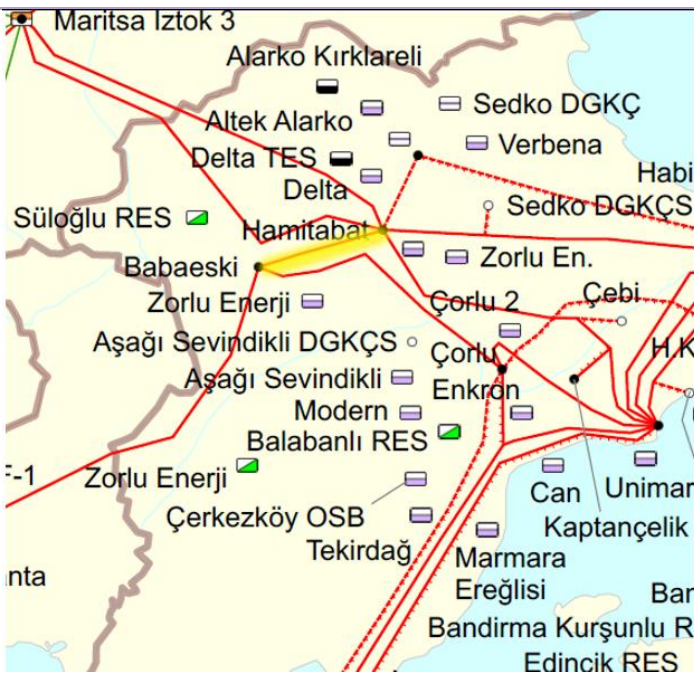
Project assessment analysis

The project consists in two interconnections: one between Greece and Turkey and one between Bulgaria and Turkey to be realized through 400kV AC overhead lines, expected to increase the interconnection capacity between Turkey and CESA of about 1000MW (500MW between Greece and Turkey and 500MW between Bulgaria and Turkey). The systems of Greece and Turkey are fully represented by their network model, while for the system of Bulgaria an equivalent representation was implemented as provided by ESO.

For this project 3 different scenarios were defined and a total number of 9 points in time were identified for the analysis. The N and N-1 static analysis applied to the transmission level identified reinforcements for the system of Greece and Turkey as detailed below, while no reinforcements were identified for the Bulgarian system.

<table>
<tr><th colspan="2">Scenario 1, 2, 3</th></tr>
<tr><th>Description (Turkey)</th><th>Description (Greece)</th></tr>
<tr><td>New OHL 400kV between Babaeski and Hamitabat</td><td>New OHL 400kV between N. Santa and Filippi</td></tr>
<tr><td>
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Project assessment analysis

The overall costs of these project are expected to be 117M€, 40% of which represents investment for internal reinforcements in Turkey and Greece related to the project. The more detailed breakdown of the cost is presented below.

Investment cost-Interconnection	
Lines	***Cost [M€]****
AC line Bulgaria	20
AC line Turkey	14
Line bay Bulgaria	2
Line bay Turkey	0.5
AC line Turkey	10
AC line Greece	20
Line bay Turkey	0.5
Line bay Greece	1
line reactor Bulgaria	0.5
line reactor Turkey	1
line reactor Greece	0.5
TOTAL	70

Investment cost –internal reinforcements	
Lines (Turkey)	***Cost [M€]****
400kV OHL Babaeski - Hamitabat (TR)	4
line bays (TR)	1
Lines (Greece)	
400kV OHL N. Santa - Filippi (GR)	40
OHL 400kV Circuit breaker (GR)	1
OHL 400kV Circuit breaker (GR)	1
TOTAL	**47**

*Rounded values

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Project cost benefit analysis results

Assessment results for the Project #11 - Greece - Bulgaria - Turkey											
GTC increase direction 1 (MW)			GR-TR:500; BG-TR:500								
GTC increase direction 2 (MW)			TR-GR:500; TR-BG:500								
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		GR	4330	4830	500	4330	4830	500	4330	4830	500
		BG	1300	1800	500	1300	1800	500	1300	1800	500
		TR	3560	4560	1000	3560	4560	1000	3560	4560	1000
GTC/NTC - Export		GR	4110	4610	500	4110	4610	500	4110	4610	500
		BG	2250	2750	500	2250	2750	500	2250	2750	500
		TR	3080	4080	1000	3080	4080	1000	3080	4080	1000
Interconnection Rate - Import/Export (%) [1]		GR	16.6% / 15.7%	18.5% / 17.6%	1.9%	11.9% / 11.3%	13.3% / 12.7%	1.4%	12.6% / 11.9%	14.0% / 13.4%	1.5%
		BG	11.4% / 19.8%	15.8% / 24.2%	4.4%	6.7% / 11.5%	9.2% / 14.1%	2.6%	8.4% / 14.5%	11.6% / 17.7%	3.2%
		TR	2.9% / 2.5%	3.8% / 3.4%	0.8%	2.8% / 2.4%	3.6% / 3.2%	0.8%	2.5% / 2.2%	3.2% / 2.9%	0.7%
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)	220	190	260	160	130	180	240	210	270
	B2 - RES Integration[3]	(GWh/y)	0	-30	30	390	270	510	130	50	190
	B3 - CO_2	(Mton/y)	-0.4	-1.2	0.5	-2.2	-2.8	-1.5	0.4	-0.6	1.0
	B4 - Losses[2]	(M€/y)	-40			-10			0		
		(GWh/y)	-890			-120			110		
	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€)	120								

[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	

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Additional Information

- Included in the latest Greek National Development Plan (under approval by the Regulator) https://www.admie.gr/en/grid/development/ten-year-development-plan
- Included in the ENTSO-E TYNDP 2018 https://tyndp.entsoe.eu/Documents/TYNDP%20documents/TYNDP2018/consultation/Main%20Report/TYNDP2018_Executive%20Report.pdf
- "Increasing electricity transfer capacity via new overhead transmission lines among Bulgaria - Turkey-Greece", IPTO, ESO-EAD, TEIAS, January 2020