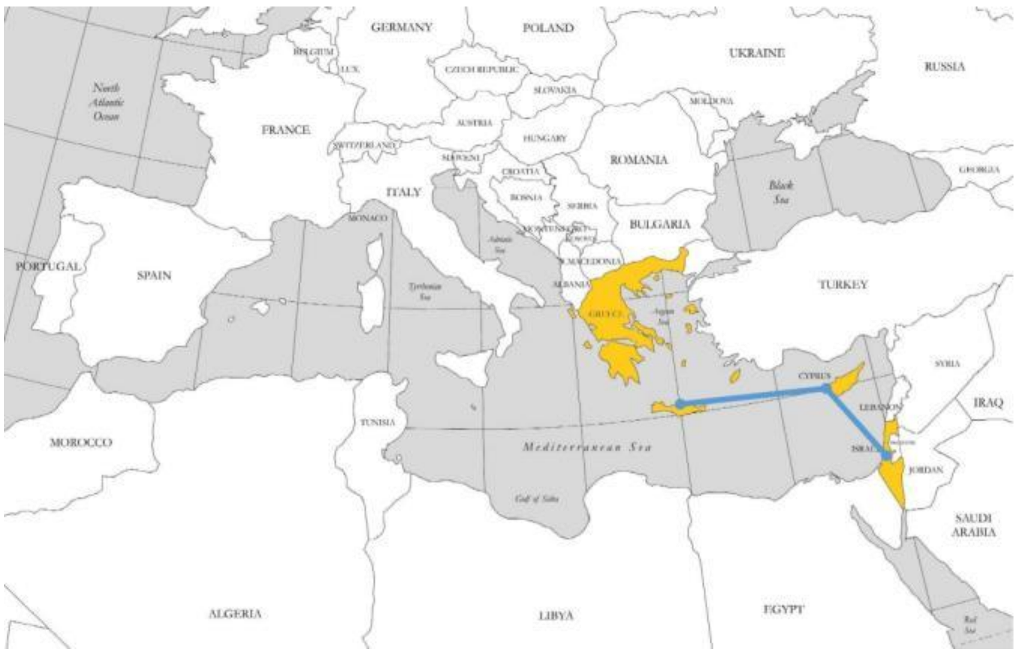
Project #12 – GREECE – CYPRUS - ISRAEL

Description

There are currently no interconnections between Greece, Cyprus and Israel.

Greece is strongly interconnected with Italy, Turkey and its Balkan neighbouring countries with 1 DC and 6 AC interconnections: one with Turkey, one with Bulgaria, two with N. Macedonia, two with Albania and one with Italy. Greece is also planning a second AC interconnection to Bulgaria (N. Santa – Maritsa), which is expected to contribute to the increase of NTC between Continental Europe Synchronous Area (CESA) and Turkey. Furthermore, the interconnection of the island of Crete to Mainland Greece is in the construction phase, namely 2 AC submarine cables from Peloponnese to Western Crete (commissioning 2020) and one HVDC link (VSC 500kV, 1000MW) from Attica to Central Crete (commissioning 2022).

Cyprus is the last member of the EU remaining fully isolated without any electricity or gas interconnections. Currently, RES penetration in the island is limited due to its autonomous operation and an increase of RES penetration, as per ambitious EU targets, would severely affect the island security of supply.



The project consists of two new interconnections: one between Greece (Crete) and Cyprus and one between Cyprus and Israel to be realized with HVDC submarine cables with a total length of around 1200 km (approx. 314 km between Cyprus and Israel, 894 km between Cyprus and Crete). The HVDC link with a capacity of 1000 MW shall be of VSC technology and allow for transmission of electricity in both directions. Nevertheless, due to stability reasons the import/export capacity seen from Cyprus power system is limited at 500 MW.

The main driver for the realization of the project is to end the energy isolation of Cyprus. The interconnection of the system of Cyprus is expected to unlock the integration of high percentage of RES and promote substantial RES development in the island, resulting in subsequent reduction of CO_2 emissions and offering significant economic and environmental benefits to the involved countries. Further to that, the project is expected to create a new transfer route between Israel-Cyprus-Crete-Greece providing mutual benefits according to the complementary characteristics and energy prices of the countries involved.

The project is promoted by IPTO and TSOC (under the umbrella of the studies carried out by Med-TSO within the Mediterranean Project I & II).

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 Cyprus (DC)	Damasta (GR – Crete)	Kofinou (CY)	1000	894	Planned (PCI TYNDP ENTSO-E)	December 2023	
New interconnection between Cyprus and Israel (DC)	Kofinou (CY)	Hadera (IL)	1000	314		December 2023	

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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 12
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	X
	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.	X
	Increase system voltage stability	Reactive power controllability of converters can be used to increase system voltage stability	x
	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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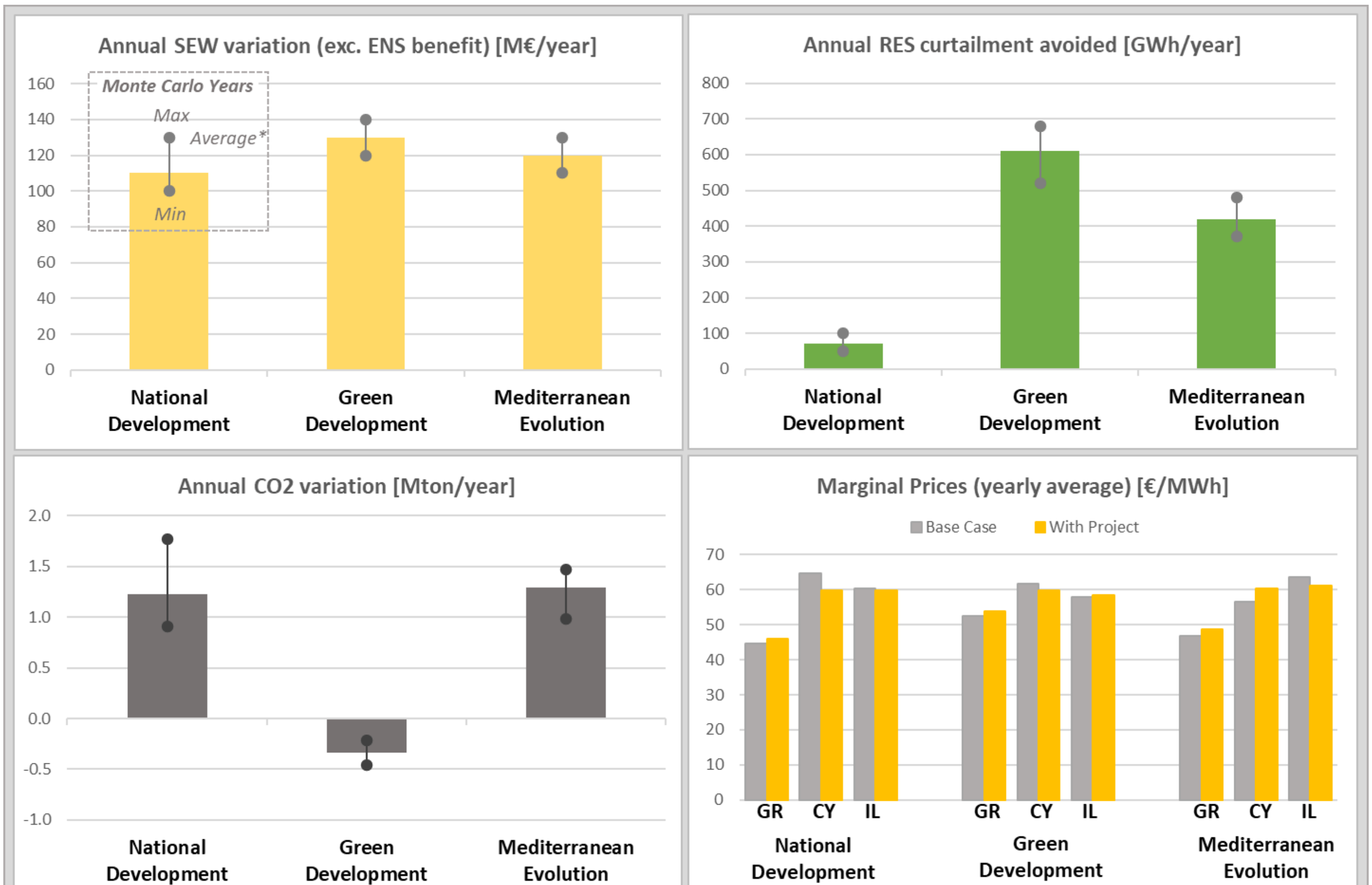
Project assessment analysis

CBA Indicators

Project 12 yields a positive impact in the expected values of all the analysed quantitative CBA indicators. Specifically, the project drives a consistent increase in the SEW and a decrease in RES curtailment, with the greater expected benefit being noticed in the Green Development and Mediterranean Evolution scenarios. Particularly for Cyprus, major positive effects of the project are the significant reduction of RES curtailment, Energy Not Supplied and loss of load duration. The impact of the project in the overall CO_2 emissions is scenario-dependent and rather negligible.



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

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Project assessment analysis

Market Studies

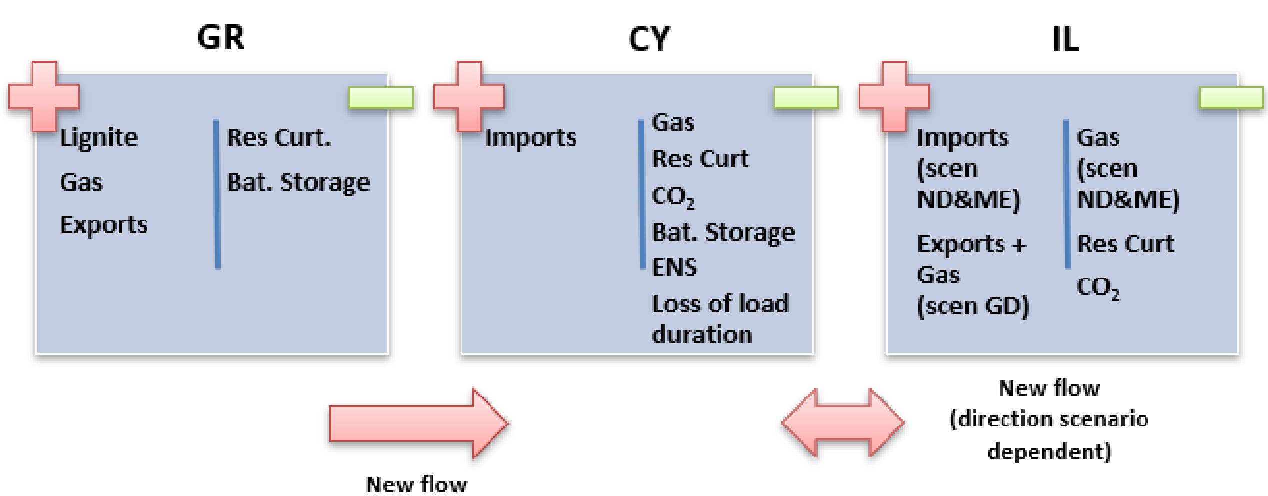
Project 12 results in substitution of gas based generation in Cyprus and Israel by lignite and gas based generation in Greece in the scenarios National Development and Mediterranean Evolution, while in the scenario Green Development an increase in gas and coal based generation is reported in Israel, which in this scenario becomes exporting country. More specifically:

- **Generation mix:**
  - **GR:** increase in lignite and gas-based generation in scenarios National Development and Mediterranean Evolution
  - **CY:** decrease in gas-based generation substituted by imports from Greece or Israel depending on the scenario
  - **IL:** decrease in gas-based generation in scenarios National Development and Mediterranean Evolution
    increase in gas and coal-based generation in the scenario Green Development

- **Country balance and cross-country power flows:** with the introduction of the project Cyprus becomes a net importer in all scenarios. In scenarios National Development and Mediterranean Evolution, considerable flows are observed in the new interconnections in the Greece to Cyprus (through Crete) and Cyprus to Israel direction, with power partly attributed to local production and partly imported. This results in an expected significant number of hours of saturation of the flow in this direction and also in a noticeable increase in the imports of Greece from its Balkan neighboring countries (Albania, Northern Macedonia and Bulgaria) and Italy. An opposite trend is observed in scenario Green Development, where Greece is relatively balanced and Cyprus is mainly importing from Israel.

<u>Note</u>:

1. The fuel and Co_2 price assumptions used for the market studies result in a lignite before gas economic merit order. However, as a result of the Greek decarbonisation program announced in early 2020, lignite-fired power plants in Greece are expected to stop their operation by 2030. The impact of this program was assessed with the simulation of an additional Scenario without lignite-fired generation in Greece, based on the National Development Scenario. This additional simulation produces results consistent with above analysis, which may be found in the detailed project assessment (link).
2. Since no data were provided to Med-TSO by the Israeli TSO, the Israeli system was modelled starting from available data and information to obtain the three contrasted data sets according to the Med-TSO scenarios storylines.



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Project assessment analysis

This project consists in a new interconnection between Greece, Cypus and Israel. The 500kV HVDC link will have a total length of about 1200km (894km from Greece to Cyprus and 314km from Cyprus to Israel) and 1000 MW capacity.

The systems of Greece (Crete included) and Cyprus are fully represented by their network models. For the system of Israel she model was not available, hence this country is represented as an external bus bar.

For this project 3 scenarios (S1, S2 and S3) were distinguished and a total number of 9 Points in time have been defined. The security analysis applied to the transmission level did not identify any necessary additional internal reinforcements for the systems of Greece and Cyprus.

The overall investment cost for this project about 2240M€. The more detailed breakdown of the cost is presented below.

Investment cost-Interconnection	
Line	***Cost [M€]****
DC cable Crete - Cyprus	1320
DC cable Cyprus - Israel	460
AC/DC converter stations Crete	150
AC/DC converter stations Cyprus	110
AC/DC converter stations Israel	150
DC underground cable	50
TOTAL	**2240**

*Rounded values

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Project cost benefit analysis results

Assessment results for the Project #12 - Greece - Cyprus - Israel											
GTC increase direction 1 (MW)			(GR-CY-IL) 1000								
GTC increase direction 2 (MW)			(IL-CY-GR) 1000								
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	5330	1000	4330	5330	1000	4330	5330	1000
		CY	0	1000	1000	0	1000	1000	0	1000	1000
		IL	0	1000	1000	0	1000	1000	0	1000	1000
GTC/NTC - Export		**GR**	4110	5110	1000	4110	5110	1000	4110	5110	1000
		CY	0	1000	1000	0	1000	1000	0	1000	1000
		IL	0	1000	1000	0	1000	1000	0	1000	1000
Interconnection Rate - Import/Export (%) [1]		**GR**	16.6% / 15.7%	20.4% / 19.6%	3.8%	11.9% / 11.3%	14.6% / 14.0%	2.7%	12.6% / 11.9%	15.5% / 14.8%	2.9%
		CY	0.0% / 0.0%	42.6% / 42.6%	42.6%	0.0% / 0.0%	35.4% / 35.4%	35.4%	0.0% / 0.0%	35.4% / 35.4%	35.4%
		IL	0.0% / 0.0%	4.5% / 4.5%	4.5%	0.0% / 0.0%	3.5% / 3.5%	3.5%	0.0% / 0.0%	3.5% / 3.5%	3.5%
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)**	110	100	130	130	120	140	120	110	130
	B2 - RES Integration [3]	**(GWh/y)**	70	50	100	610	520	680	420	370	480
	B3 - CO_2	**(Mton/y)**	1.2	0.9	1.8	-0.3	-0.5	-0.2	1.3	1.0	1.5
	B4 - Losses [2]	**(M€/y)**	90			40			50		
		(GWh/y)	1760			780			840		
	B5a - SoS Adequacy [4]	**(GWh/y)**	0.3	0.0	2.7	0.0	0.0	0.0	0.6	0.0	3.1
		(M€/y)	0.9	0.0	8.1	0.5	5.3	0.0	1.7	0.0	9.3
	B5b - SoS System Stability										
Residual Impact Indicators	**S1 - Environmental Impact**										
	S2 - Social Impact										
	S3 - Other Impact										
Costs	**C1 - Estimated Cost** [5]	**(M€)**	2240								

[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	yellow