Beyond the cable: Energy security, cost recovery and the Eastern Mediterranean as an emerging electricity corridor

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Abstract

The Great Sea Interconnector (GSI), a planned 1,208km, 500kV HVDC subsea link between Crete, Cyprus, and Israel, is routinely evaluated through a narrow lens: how much must a single country pay? This framing obscures three features that determine whether the project is a net benefit or a net cost to Cyprus. First, under EU Regulations 2019/943 and 2022/869, cost recovery for a Project of Common Interest (PCI) is residual: grants and congestion-rent market revenue are deducted before any Cross-Border Cost Allocation (CBCA) reaches regulated tariffs, so a headline capital figure or a fixed allocation ratio (63/37 for the Cyprus–Crete segment) systematically overstates the likely consumer impact. Second, a parametric sensitivity analysis of the net benefit per kilowatt-hour transferred, defined as wholesale price convergence minus the GSI usage charge minus reserve costs, shows that the interconnector is economically favourable across a wide, policy-relevant parameter space, with annual system value ranging from approximately €M22 to over €M240 depending on utilisation and net-benefit assumptions. Third, and increasingly salient, the GSI is no longer a bilateral cable. It is being positioned by the EU, the United States, and Gulf and South Asian partners as the westward terminus of the India–Middle East–Europe Economic Corridor (IMEC), with a subsequent Cyprus–Israel segment now at the regulatory investment-request stage. Any techno-economic or policy assessment of the GSI that omits energy security value and IMEC-related option value understates its strategic worth, which is why this report introduces a benefit-accounting framework that separates near-term consumer cost exposure from long-term strategic and security value.

Introduction

Cyprus is the only European Union member state whose electricity system remains electrically isolated from the rest of the Union. This isolation carries a quantifiable technical cost. The island must maintain disproportionate operating reserves, cannot participate in the EU internal electricity market and faces structural limits on renewable energy integration because there is no external grid to absorb surplus variable generation or to import power during shortfalls.

The Great Sea Interconnector (GSI, formerly the EuroAsia Interconnector) is the EU-designated Project of Common Interest intended to end that isolation by linking Crete, Cyprus, and Israel via a high-voltage direct-current (HVDC) submarine cable system. The project was included in the Union list of Projects of Common Interest from the first Union list adopted in 2013 under Regulation (EU) No. 347/2013 on guidelines for trans-European energy infrastructure. Since its inclusion, the Republic of Cyprus has continued to support the interconnector as a project of strategic importance for ending the island's electricity isolation, integrating Cyprus into the European electricity market, and strengthening regional energy security. The Crete–Cyprus segment (898 km, 1,000MW at 500kV) is under construction and co-financed by the EU's Connecting Europe Facility with approximately €M657 in grants. A second, 324km segment linking Cyprus to Israel, with a rated capacity of 1,000MW at 500kV, has now reached the formal investment-request stage before the Cypriot and Israeli energy regulators. With the completion of the electricity interconnection, all existing derogations granted to Cyprus from the EU electricity acquis in the field of electricity will be removed.

Total project cost estimates Crete–Cyprus segment around €B1.9. Public debate around the GSI in Cyprus has concentrated almost exclusively on this contribution figure and on anticipated consumer tariff impacts. Such a framing is analytically incomplete in three specific, addressable ways: (i) it conflates gross project cost with the actual regulated tariff impact, which is residual after market revenue and grants are netted out, (ii) it typically omits a proper parametric accounting of the net benefit per unit of energy transferred and (iii) it disregards the option value created by the GSI's emerging role as the Eastern Mediterranean gateway of the India–Middle East–Europe Economic Corridor (IMEC), including the prospective Cyprus–Israel electricity interconnection and further eastward extensions.

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Cost recovery is residual, not additive

A recurring misconception in the Cypriot public discourse treats the GSI's capital cost of €B1.9, or the Cyprus–Crete CBCA allocation ratio, as though it translated directly and in full into a consumer tariff. Under Regulation (EU) 2019/943, revenue from congestion-rent auctions on cross-border transmission capacity is applied first against a project's annual allowed revenue. Only the residual, uncovered amount is eligible for cost recovery through the CBCA mechanism established under Regulation (EU) 2022/869 for Projects of Common Interest.

For the Cyprus–Crete segment, national regulators have determined a 63%/37% cost allocation between Cyprus and Greece, reflecting the relative net benefit each country was assessed to receive in the investment request studies. Critically, this ratio applies only to the residual amount left after (a) EU grants (€M657 already secured for this segment) and (b) congestion-rent market revenue have been deducted from the annual allowed revenue. For example, if the annual allowed revenue requiring recovery is €M10 and market congestion revenue contributes €M7, only €M3 is subject to CBCA allocation, yielding approximately €M1.89 for Cyprus and €M1.11 for Greece, not the full €M6.3 and €M3.7 that a naive application of the ratio to the gross figure would suggest. If market revenue meets or exceeds the allowed revenue in a given year, no further tariff-based recovery is triggered at all, and any surplus is, depending on the regulatory framework, available to offset future consumer charges.

This distinction matters for techno-economic modeling of interconnector projects. Generally capital cost, allocation ratio, and consumer tariff impact are three distinct quantities linked by a market-revenue netting step that is frequently omitted from public and even semi-technical analysis.

A parametric accounting of net consumer benefit

To assess the economic case independent of long-run electricity price forecasts, we developed a parametric sensitivity model of the net benefit per kWh delivered through the GSI's Cyprus-facing capacity, rather than a point forecast. The commercial transfer capacity is set at 500MW, consistent with an N$-$1 security criterion applied to the nominal rating, and utilization is varied from 50% to 100% of the theoretical annual energy ceiling of $500\text{MW} \times 8{,}760\text{h} = 4.38\text{TWh/year}$.

The net benefit NB (c/kWh) transferred is:

$$NB = P_B - C_{\mathrm{GSI}} - C_R, \tag{1}$$

where P_B is the wholesale price-convergence benefit (c/kWh), C_{GSI} is the regulated GSI usage charge (c/kWh), and C_R is the incremental reserve cost associated with secure interconnected operation (c/kWh). The units of NB, P_B, C_{GSI}, and C_R are homogeneous (all in c/kWh), which ensures that Equation (1) is dimensionally consistent. The annual system value V of the interconnector, in €/year, is then obtained by multiplying the net benefit per kilowatt-hour by the annual energy transferred:

$$V = NB \times E_{\mathrm{GSI}}, \tag{2}$$

where E_{GSI} is the total annual energy scheduled over the Cyprus-facing capacity of the GSI, expressed in kilowatt-hours (kWh). To connect the interconnector-specific quantities to the total Cypriot electricity bill, we define:

$$\text{Impact} = NB \times \frac{E_{\mathrm{GSI}}}{E_{\mathrm{CY}}}, \tag{3}$$

where E_{CY} is the total annual electricity consumption in Cyprus (kWh/yr). The ratio $E_{\mathrm{GSI}}/E_{\mathrm{CY}}$ is dimensionless and represents the share of total consumption served via the interconnector. Equation (3) shows that even a relatively large net benefit per kilowatt-hour on the interconnector translates into a more modest average impact on the total bill if the share of energy carried by the GSI is limited.

Definition of variables and units

Equation (1) expresses the net consumer benefit per unit of electricity transferred through the GSI in c/kWh. For clarity, we summarise here the meaning, units, and interpretation of each term:

- NB is the *net benefit per unit of energy transferred* via the interconnector, measured in c/kWh. A positive value of NB indicates that, on average, consumers in Cyprus pay less for each kilowatt-hour imported through the GSI than they would in the counterfactual without the interconnector, once usage charges and reserve costs are included. The underlying source of this benefit is *market coupling*, that is once Cyprus is electrically connected to the Greek and wider EU internal electricity market via the GSI, the two previously separate wholesale markets are no longer priced independently. Under the EU's Single Day-Ahead Coupling (SDAC) mechanism, a joint algorithm, operated by the connected power exchanges and transmission system operators, simultaneously clears the day-ahead markets on both sides of the interconnector each hour, allocating the available cross-border transmission capacity implicitly to the trades with the highest arbitrage value. In practice, this means that whenever the unconstrained Cypriot wholesale price would otherwise exceed the Greek price, the algorithm schedules a flow of electricity from Greece to Cyprus (i.e., import via the GSI) up to the available commercial capacity, and the Cypriot day-ahead clearing price falls towards the Greek price. The reverse occurs, with Cyprus exporting to Greece, in the comparatively rare hours when the unconstrained Cypriot price is lower.
- P_B is the *wholesale price-convergence benefit*, also in c/kWh. It represents the average reduction in the Cypriot wholesale electricity price per kilowatt-hour attributable to market coupling via the GSI. That is the ability to import cheaper power from the interconnected Greek/EU market in hours when the unconstrained Cypriot price would otherwise be higher, or to export surplus Cypriot generation in the comparatively rare hours when the reverse holds. In practice, P_B is derived from hourly or sub-hourly price-difference time series between the Cypriot system and the relevant interconnected markets. Thus, P_B magnitude depends on the empirical, hour-by-hour outcome of market coupling rather than on a value that can be fixed *ex ante*.
- C_{GSI} is the *regulated usage charge of the Great Sea Interconnector*, in c/kWh. It captures the tariff levied on each kilowatt-hour of energy scheduled over the Cyprus-facing capacity of the GSI, and is the mechanism through which the residual allowed revenue, the amount left over after grants and congestion-rent market revenue have been netted out of the total allowed annual revenue is ultimately recovered from consumers, together with any regulated return on. By construction, C_{GSI} is a *volumetric* charge. The regulator set this, typically on an annual or multi-year basis, such that $C_{\mathrm{GSI}} \times E_{\mathrm{GSI}}$ recovers the residual revenue requirement over the relevant energy volume E_{GSI} actually scheduled over the interconnector that year. This has an important practical implication that parallels the treatment of P_B. Because C_{GSI} is defined as a rate per kilowatt-hour rather than a fixed annual sum, its effective burden on any individual consumer depends on the realized utilization of the GSI, and its calibration by the regulator depends, in turn, on a forecast of that same utilization, creating a circularity that is typically resolved through periodic tariff true-ups rather than a single ex-ante rate.
- C_R is the *incremental reserve cost* associated with secure operation of the interconnected system, again in c/kWh. It reflects any additional expenditure on operating reserves that the transmission system operator must incur to maintain N$-$1 security once the GSI is in service, relative to the islanded case. In practice, C_R is obtained by converting the transmission system operator's incremental reserve procurement cost (€/year), relative to the counterfactual islanded reserve requirement, into a per-kilowatt-hour figure using the annual energy transferred through the GSI, i.e., $C_R = (\text{incremental reserve procurement cost})/E_{\mathrm{GSI}}$. This mirrors the construction of C_{GSI} above and inherits the same circularity. The reserve cost allocated to each kilowatt-hour depends on the realized utilization of the link, while the reserve requirement itself is set *ex ante* based on a forecast of that utilization and of the interconnector's availability. Unlike C_{GSI}, however, C_R is not a component of the CBCA-recovered allowed revenue. It is typically settled through separate balancing or ancillary-service markets, which is why it is treated here as an additive term alongside C_{GSI} rather than folded into the residual-revenue calculation.

Parametric sensitivity analysis: break-even and system value

Equation (1) defines the net benefit NB as the difference between the wholesale price-convergence benefit P_B and the combined usage-plus-reserve charge $C_{\mathrm{GSI}} + C_R$. Because each of these three terms is properly treated as an empirically determined, time-varying quantity rather than a value that can be fixed in advance, we do not attempt to forecast a single value for NB. Instead, we characterize the full space of outcomes parametrically, and we use that parametric space to establish (i) the break-even condition under which the GSI is favorable to consumers, (ii) the sensitivity of NB to plausible ranges of its two driving components, and (iii) the translation of a per-kilowatt-hour benefit into system-level and bill-level euro values.

Setting $NB = 0$ in Equation (1) and rearranging yields the minimum wholesale price-convergence benefit required for the interconnector to be economically favourable on a per-kilowatt-hour basis, for a given combination of usage charge and reserve cost:

$$P_B^{\min} = C_{\mathrm{GSI}} + C_R, \tag{4}$$

where $P_B^{\min}$ is the threshold value of P_B (c/kWh) at which NB becomes zero. For $P_B > P_B^{\min}$, Equation (1) yields $NB > 0$ and the interconnector is economically favorable; for $P_B < P_B^{\min}$, the net benefit is negative and additional justification must come from the exporting electricity, energy security and corridor-value considerations discussed in the sections that follow.

Table 1 reports NB across a plausible range of P_B (2–10 c/kWh) against the combined charge $C_{\mathrm{GSI}} + C_R$ (1–9 c/kWh). Because $NB = P_B - C_{\mathrm{GSI}} - C_R$, NB is positive across roughly half of the parameter space explored.

Table 1: Net benefit NB (c/kWh) of energy transferred via the GSI, as a function of wholesale price-convergence benefit (P_B) and combined usage-plus-reserve charge ($C_{\mathrm{GSI}} + C_R$). *Positive values (shown in blue) denote net consumer benefit. Negative values (shown in red) denote parameter combinations where the average net benefit NB is below zero; they remain compatible with hours in which Cyprus exports electricity via the GSI and monetizes surplus renewable generation.*

	Net benefit NB (c/kWh)				
P_B	$C_{\mathrm{GSI}} + C_R$=2	$C_{\mathrm{GSI}} + C_R$=4	$C_{\mathrm{GSI}} + C_R$=6	$C_{\mathrm{GSI}} + C_R$=8	$C_{\mathrm{GSI}} + C_R$=10
2	0.0	−2.0	−4.0	−6.0	−8.0
4	+2.0	0.0	−2.0	−4.0	−6.0
6	+4.0	+2.0	0.0	−2.0	−4.0
8	+6.0	+4.0	+2.0	0.0	−2.0
10	+8.0	+6.0	+4.0	+2.0	0.0

Out of the 25 combinations tabulated, 10 yield a positive net benefit, 5 yield exact break-even where $P_B = 0$ and the remaining 10, concentrated in the low-P_B, high-$C_{\mathrm{GSI}} + C_R$ corner, yield negative values. In particular, for $P_B = 8$ c/kWh, NB remains non-negative for every combined-charge assumption considered up to $C_{\mathrm{GSI}}+C_R = 8$ c/kWh and only turns negative at $C_{\mathrm{GSI}}+C_R = 9$ c/kWh. This pattern is the numerical counterpart of the break-even condition in Equation (4). Moving down a column (increasing P_B) always increases NB one-for-one and moving across a row (increasing $C_{\mathrm{GSI}} + C_R$) always decreases NB one-for-one, since both enter Equation (1) linearly.

A negative NB in Table 1 should not be read as evidence that the GSI is unfavorable in an absolute sense. It is specifically a statement about the *import-side* economics of the interconnector under the stated combination of P_B and $C_{\mathrm{GSI}} + C_R$. As noted above, P_B is derived from the average, hour-by-hour outcome of Single Day-Ahead Coupling between the Cypriot and Greek/EU markets. Under SDAC, the joint clearing algorithm schedules a flow from Greece to Cyprus (import) whenever the unconstrained Cypriot price would otherwise exceed the Greek price, but it schedules the reverse flow, Cyprus exporting to Greece, in hours when the unconstrained Cypriot price is lower. Both directions of flow occur over the same interconnector and are compressed into the single, average, net figure P_B used throughout this analysis.

Consequently, a negative cell in Table 1, for example, $[P_B, (C_{\mathrm{GSI}} + C_R)] = (2, 9)$, giving $NB = -7.0$ c/kWh, indicates that the *net* outcome of the price-convergence channel, averaged across both import and export hours, is insufficient to cover the combined usage-plus-reserve charge. It does not imply that Cyprus never benefits from the interconnector in that scenario. In the subset of hours captured within that average where the unconstrained Cypriot price is below the Greek price, the GSI is earning export revenue for Cypriot generators, effectively monetizing domestic surplus generation, most plausibly surplus renewable output during periods of high solar or wind availability, that would otherwise be curtailed. This export-side benefit is netted into P_B together with the more frequent import-side benefit and a negative table entry simply means the import-side charge burden dominates the blended annual average, not that export hours contribute zero or negative value on their own.

Table 2 applies Equation (2) at the interconnector 500MW commercial capacity, across utilization levels from 50% to 100% of the theoretical annual ceiling ($500\mathrm{MW} \times 8{,}760\mathrm{h} = 4.38\mathrm{TWh}$/year), for three representative values of NB.

At 500MW and a representative $NB = 2.5$ c/kWh, the annual system benefit ranges from €M54.8 at 50% utilization to €M109.5 at full utilization. Because V is linear in both NB and

Table 2: Annual system value of GSI operation at 500 MW commercial capacity, by utilisation level and representative net benefit (NB).

Utilisation	Energy (TWh/yr)	NB=1.0 (€M/yr)	NB=2.5 (€M/yr)	NB=5.5 (€M/yr)
50%	2.19	21.9	54.8	120.5
70%	3.07	30.7	76.6	168.6
80%	3.50	35.0	87.6	192.7
100%	4.38	43.8	109.5	240.9

E_{GSI}, each additional 1c/kWh of net benefit is worth approximately €M21.9/year at 50% utilization and €M43.8/year at 100% utilization. Converting the system-level value in Table 2 into an equivalent per-kWh impact on the total Cypriot electricity bill requires one further step as given by Equation 3. This step is frequently skipped in public discussion of the GSI, which leads to an apples-to-oranges comparison between an interconnector-specific charge or benefit (expressed per kWh transferred through the GSI) and total household consumption (expressed per kWh of the entire bill). Equation (3) makes explicit that even a relatively large NB on the interconnector translates into a more modest average bill impact whenever the GSI serves only a fraction of total consumption. We apply Equation (3) numerically in Example 2 below.

Figures 1–4 present the four relationships developed above in graphical form, generated directly from the parametric model underlying Tables 1 and 2. Figure 1 plots annual energy transferred through the GSI, E_{GSI}, against utilization, ranging from 50% to 100%. The relationship is exactly linear, rising from 2.19TWh/yr at 50% utilization to 4.38TWh/yr at 100% utilization, and it is this quantity that scales the per-kilowatt-hour net benefit NB into the annual system value V via Equation (2). Figure 1 therefore provides the volume axis that underlies every subsequent euro-denominated result.

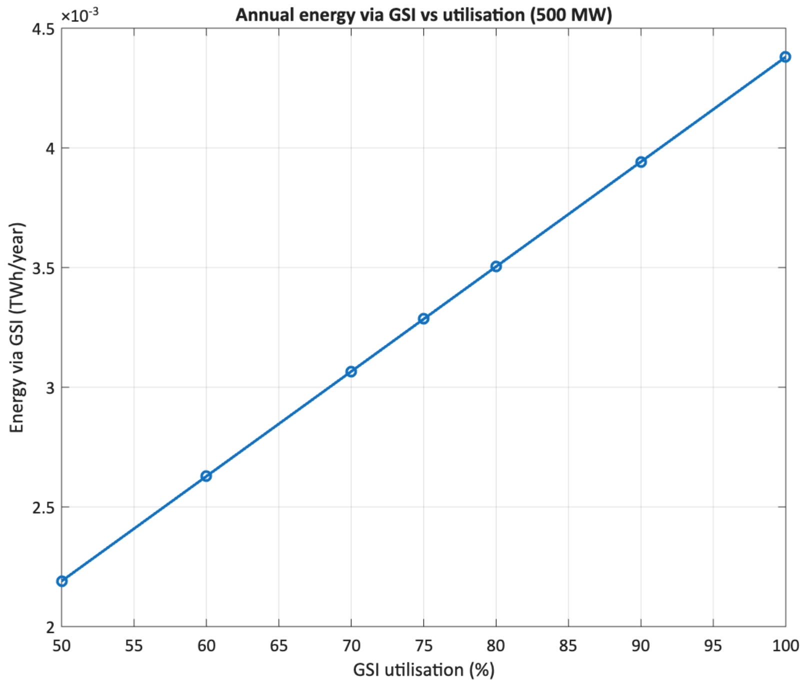

Figure 1: Annual energy via GSI *vs* utilization.

Figure 2 presents the net-benefit heatmap corresponding to Table 1, with color encoding the resulting value of $NB = P_B - C_{\mathrm{GSI}} - C_R$. The superimposed black contour marks the break-even locus $NB = 0$, i.e., the graphical representation of Equation (4): combinations lying above and to the left of the contour (high $C_{\mathrm{GSI}} + C_R$, low P_B) correspond to a negative value, shown in the cooler (blue) region of the color map, while combinations below and to the right (low $C_{\mathrm{GSI}} + C_R$, high P_B) correspond to a net benefit, shown in the warmer (yellow) region. The break-even contour is a straight diagonal line because Equation (4) is linear in both variables; Figure 2 makes visually explicit the same information tabulated numerically in Table 1, while covering the full continuous parameter space rather than the five discrete columns shown in the table.

Figure 3 translates the per-kilowatt-hour sensitivity of Figure 2 into the annual system-value

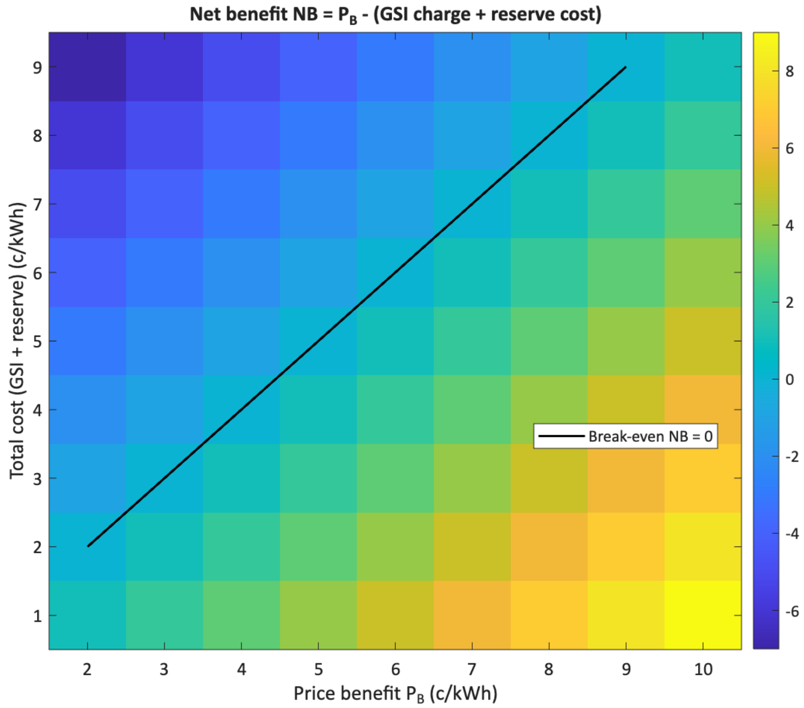

Figure 2: Net benefit heatmap: $NB = P_B - C_{\text{GSI}} - C_R$, with break-even contour $NB = 0$.

terms of Table 2, plotting V (€M/year) against utilisation for four representative values of NB (1.0, 2.5, 4.0, and 5.5 c/kWh). Each line is linear in utilization, consistent with the linearity of Equation (2) in E_{GSI} and the vertical separation between lines at any given utilization level is proportional to the difference in NB, illustrating that the annual value of the interconnector is highly sensitive to which point in the NB sensitivity range (Figure 2) is ultimately realized in practice. At 100% utilization, annual value ranges from €M43.8 ($NB = 1.0$c/kWh) to €M240.9 ($NB = 5.5$c/kWh).

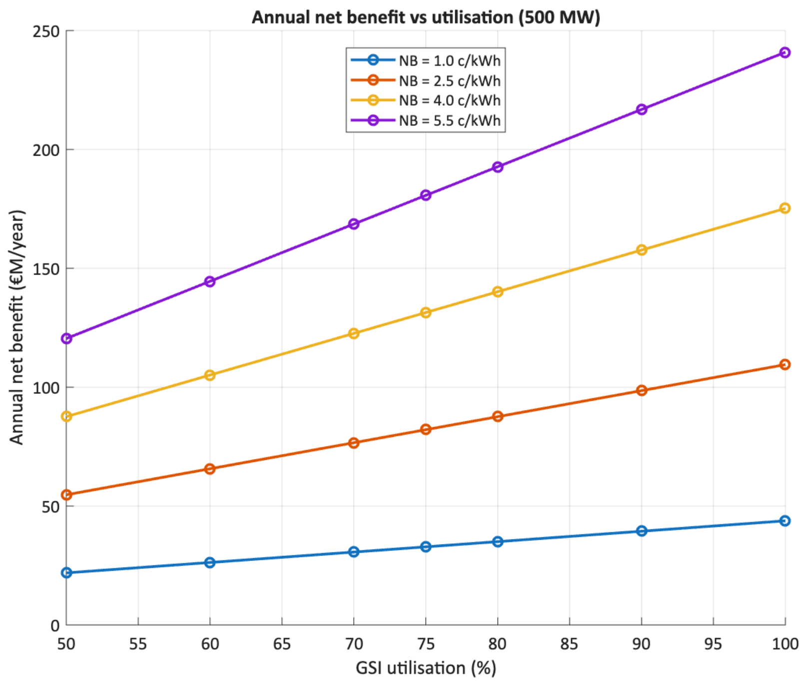

Figure 3: Annual net benefit *vs* utilization, for representative values of NB.

Figure 4 combines the two preceding figures into a single three-dimensional (contour) surface of annual net benefit V as a joint function of NB and utilization, over the same ranges used in Figure 3. The surface rises monotonically in both dimensions, confirming that utilization and net benefit per kilowatt-hour act as independent, multiplicative levers on system value, as implied algebraically by Equation (2). Doubling either quantity (holding the other fixed) approximately doubles V, while improvements in both simultaneously compound. Figure 4 is intended as a single reference diagram from which a reader can read off an approximate annual value for any combination of assumed net benefit and expected utilization, without needing to interpolate between the discrete rows of Table 2.

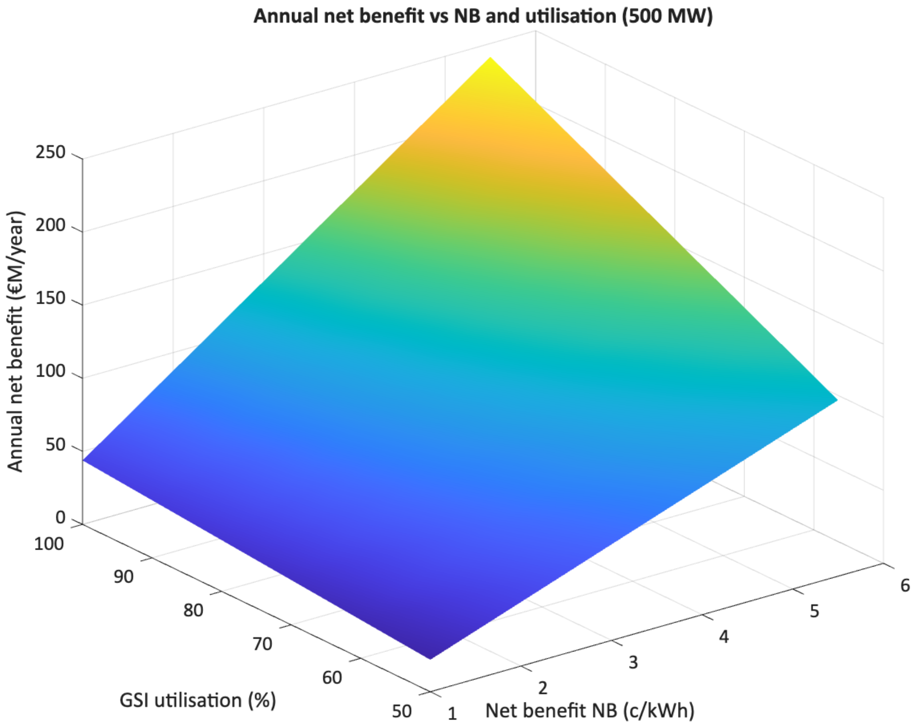

Figure 4: Annual net benefit *vs* NB and utilization: combined sensitivity surface.

Taken together, Figures 1–4 and Tables 1–2 deliberately avoid forecasting a single future electricity price or a single realized utilization rate. Instead, they make explicit the conditions under which the GSI is economically favorable to consumers across the full space of policy-relevant assumptions, and they show that break-even is reached well within the range of price differentials already observed between islanded and interconnected Mediterranean power systems.

Numerical worked examples

The parametric relationships and figures above are illustrated below with two fully worked numerical examples: (1) translating that system value into an average impact on the total Cypriot electricity bill and (2) applying the CBCA residual-allocation mechanism to a stylized annual revenue scenario. These examples use the same notation and equations introduced above and are not re-derived from first principles here.

Example 1: Impact on the average Cypriot electricity bill

Applying Equation (3), assume for illustration that total annual electricity consumption in Cyprus is $E_{\mathrm{CY}} = 4.5\mathrm{TWh/year}$, that the GSI operates at 50% utilization ($E_{\mathrm{GSI}} = 2.19\mathrm{TWh/year}$, as in Table 2) and that $NB = 2.5\mathrm{c/kWh}$. The share of total consumption served via the interconnector is

$$\frac{E_{\mathrm{GSI}}}{E_{\mathrm{CY}}} = \frac{2.19}{4.5} \approx 0.49, \tag{5}$$

so that the average impact on the total bill is

$$\mathrm{Impact} \approx 2.5\ \mathrm{c/kWh} \times 0.49 \approx 1.2\ \mathrm{c/kWh}. \tag{6}$$

In other words, a net benefit of 2.5c/kWh on the interconnector, applied to roughly half of total consumption, translates into an average reduction of about 1.2c/kWh on the overall Cypriot electricity bill. If the utilization rate or the net benefit per kilowatt-hour were higher, for example, the $NB = 5.5\mathrm{c/kWh}$, 100% utilization case in Table 2, the corresponding impact would increase proportionally, illustrating why Equation (3) rather than NB alone should be used whenever the comparison of interest is to the total household bill rather than to the interconnector-specific charge.

Example 2: CBCA allocation when allowed revenue is not fully covered

Recall that the CBCA mechanism under Regulation (EU) 2022/869 applies to the residual annual allowed revenue $R_{\text{res}} = R - G - M$, where R is the annual allowed revenue for the Cyprus–Crete segment, G is the annualized value of EU grants, and M is annual congestion-rent market revenue, all in €/year; the residual is allocated 63%/37% between Cyprus and Greece.

Consider the stylized case discussed in the main text, in which the annual allowed revenue requiring recovery is €M10 and congestion rents contribute €M7, with grants already accounted for. In this case,

$$R_{\text{res}} = €\text{M}10 - €7 = €\text{M}3, \tag{7}$$

so that

$$R_{\text{CY}} = 0.63 \times €\text{M}3 \approx €\text{M}1.89, \qquad R_{\text{GR}} = 0.37 \times €\text{M}3 \approx €1.11. \tag{8}$$

If, in a subsequent year, congestion rents increase to €M10 while the allowed revenue remains €10 million, then

$$R_{\text{res}} = €\text{M}10 - €\text{M}10 = 0, \tag{9}$$

and no CBCA-based recovery is triggered, that is, Cyprus and Greece recover nothing through regulated tariffs for that year, and any surplus market revenue may be carried forward or used to offset future tariff requirements, depending on regulatory rules.

These numerical examples highlight that the 63%/37% CBCA ratio applies only to the residual amount after grants and congestion rents, not to the gross allowed revenue. As a result, the effective annual tariff impact on consumers is substantially smaller than what a naive application of the ratio to the headline revenue figure would suggest.

Energy security value is a missing term

The sensitivity analysis above captures only the wholesale-price-arbitrage channel of benefit. It excludes what is arguably the GSI's largest single value component for Cyprus: *Energy Security*. An islanded power system with no external synchronous or asynchronous support must carry reserve margins, generation redundancy, and fuel-security buffers that a well-interconnected system does not require to the same degree. The cost of this isolation is not a single line item. It is distributed across higher reserve requirements, constrained renewable curtailment thresholds, exposure to single-fuel-source disruption and forgone access to EU balancing and capacity markets.

The EU itself has formally recognized this dimension, characterizing the GSI as a project that will end Cyprus's electrical isolation, support decarbonization, and strengthen the resilience of the European energy system. From a techno-economic modeling perspective, energy security value should be treated as a distinct benefit stream, not folded implicitly into the price-convergence term P_B, because it persists even in periods when wholesale price differentials are small or transiently negative (for example, during periods of high Cypriot renewable output). A complete cost–benefit accounting of the GSI, and of any comparable island-to-mainland interconnector, should therefore report at minimum three separate benefit categories: (a) wholesale price convergence, (b) avoided reserve and redundancy cost under N$-$1-consistent islanded operation and (c) resilience value against correlated regional supply shocks (e.g., fuel supply disruption, extreme weather, or geopolitical interruption of a single import route).

A further refinement is required to avoid conflating the GSI's energy security contribution with that of a second, complementary flexibility resource that is simultaneously being deployed in the Cypriot system: *energy storage*. Storage and interconnection are both flexibility instruments, but they operate along fundamentally different dimensions and are therefore not substitutes for one another in a cost–benefit framework. Storage moves energy *across time*, charging when generation (typically solar) exceeds demand and discharging when the reverse holds, whereas interconnection moves energy *across space*, importing when a neighbouring system has a lower marginal cost of generation and exporting when the reverse holds. The greater the share of variable renewable generation in the system, the more valuable both dimensions of flexibility become, but they address different failure modes and should be accounted for separately rather than treated as interchangeable sources of energy security value.

This distinction has direct implications for curtailment mitigation, which is frequently cited as a shared benefit of both technologies. Energy-limited storage (e.g., a battery sized for two to four hours of discharge) can shift surplus renewable output from midday to evening peak within the same day, but it has only a limited ability to mitigate curtailment during *extended* periods of low demand or persistently high renewable output spanning multiple days, since its energy capacity, not just its power rating, becomes the binding constraint. Interconnection, by contrast, is not constrained by an onboard energy reservoir. As long as the neighboring system has spare demand or absorption capacity, the GSI can export surplus Cypriot renewable generation indefinitely, subject only to its rated transfer capacity, making it the more scalable curtailment-mitigation instrument as renewable penetration rises towards very high shares. Conversely, storage retains an advantage that interconnection cannot replicate. Fast frequency response, inertial support and voltage control delivered locally and near-instantaneously, which are essential for maintaining system stability during the fractions of a second immediately following a generation or load disturbance, before any interconnector's power flow can be adjusted.

For Cyprus specifically, this implies that storage and the GSI address complementary, not overlapping, components of energy security. Storage principally reduces the *intraday* reserve and curtailment burden associated with high solar penetration, while the GSI principally reduces the *structural* isolation cost associated with having no external system to draw upon during prolonged shortfalls, extreme weather events, or single-fuel-source disruptions. A cost–benefit framework that credits either technology with the other's distinct contribution, for instance by assuming that a large battery fleet renders the GSI's security-of-supply value redundant, or vice versa, would misstate the marginal value of both. We therefore extend the three benefit categories proposed above with an explicit fourth category: (d) flexibility-dimension differentiation, requiring that any techno-economic assessment of the GSI report its avoided-reserve and curtailment-mitigation value net of, and separately from, the contribution already attributable to battery storage and other temporal-flexibility resources deployed in parallel.

From bilateral cable to IMEC gateway

The strategic context of the GSI has shifted materially since the project's original conception as a Greece–Cyprus interconnection. Three developments are notable. First, the entry of the French infrastructure investor Meridiam as majority shareholder in the Great Sea Interconnector special-purpose vehicle has strengthened the project's financial and technical maturation prospects. Second, the Cyprus–Israel segment has progressed from concept to a formal investment request submitted by IPTO/ADMIE to the Cypriot and Israeli energy regulators, specifying a 324km, 1,000MW, 500kV HVDC link between Cyprus and Greece. Third, and most consequentially for the project's geopolitical framing, the GSI is explicitly named in the U.S. Senate's Eastern Mediterranean Gateway Act (S.4443) as critical infrastructure supporting the role of Eastern Mediterranean countries as the strategic gateway of the India–Middle East–Europe Economic Corridor (IMEC), alongside the GREGY interconnector, the Greece–Bulgaria interconnector and regional LNG terminals.

IMEC itself, launched in September 2023 via a memorandum of understanding among India, the United States, Saudi Arabia, the UAE, France, Germany, Italy, and the EU, envisages transport, energy and digital corridors spanning approximately 4,800km, including subsea electricity interconnections alongside hydrogen pipelines and fibre-optic links. A November 2025 trilateral energy ministerial in Athens involving the United States, Greece, Cyprus, and Israel reaffirmed IMEC and the Eastern Mediterranean Energy Centre as pillars of regional energy security and strategic stability.

Quantitative modeling of this longer corridor[1] indicates the scale of what is at stake. A large-scale, hourly-resolved optimization of a prospective 5GW HVDC corridor spanning roughly 3,730km, from 10 GW of combined solar and wind capacity in India, the UAE, and Saudi Arabia, through Israel and Cyprus, into the Greek and EU internal electricity market, projects annual energy flows of approximately 19.9TWh generated, of which 13.4TWh would reach EU markets and 2.7TWh would serve Israel, with delivered electricity costs averaging approximately 3.8c/kWh at the EU border. The same study estimates capital expenditure requirements of €B13–21 across submarine and land HVDC cable, converter stations and supporting infrastructure, alongside more than 13,000 construction jobs, roughly 3,600 permanent positions and approximately €B1 in annual transit-fee and export revenue potential across the corridor countries.

These figures are indicative outputs of a specific optimization exercise, not a committed investment plan, and should be read as an order-of-magnitude illustration of the corridor's technical feasibility rather than a forecast. Nonetheless, they establish that the GSI's Cyprus–Israel segment

[1] IMEC Electricity Interconnection: Strategic Corridor for EU Decarbonization India–Middle East–Europe Economic Corridor Energy Analysis Outlook, `https://www.frederick.ac.cy/images/IMEC_NewsLetter_EN.pdf`

is not merely a bilateral security-of-supply interconnector. It is the segment that would need to exist, at minimum, for Cyprus and Greece to serve as an EU entry point for renewable electricity originating well beyond the Eastern Mediterranean. This reframes the appropriate evaluation horizon for Cypriot and European policymakers from a single-project cost-recovery question to a corridor-positioning question with option value extending decades into the future.

Implications for evaluation practice

We draw three implications for how the GSI, and comparable strategic interconnectors, should be evaluated in techno-economic and policy analysis.

First, cost-recovery mechanics should be modeled explicitly rather than assumed. Reporting a CBCA allocation ratio without the associated congestion-rent netting step overstates the likely consumer tariff impact and distorts public debate. We recommend that national regulators and project promoters publish, alongside the allocation ratio, an annual reconciliation showing allowed revenue, market revenue collected and the residual amount recovered through tariffs.

Second, sensitivity-based net-benefit accounting, of the kind presented in Table 1, should be preferred over single-point price forecasts for public communication, because it demonstrates the conditions for viability without requiring contestable long-run price assumptions. Break-even analysis is more robust to scrutiny and more transparent than a single projected saving figure.

Third, energy security value and corridor option value (via IMEC and prospective further eastward links) should be reported as explicit, separate benefit categories in any updated GSI cost–benefit assessment, alongside the traditional price-convergence term. Omitting them is not conservative. It is simply incomplete, since these values do not appear in wholesale price differentials but materially affect the project's strategic return to Cyprus, Greece, and the wider EU electricity system.

Conclusion

The Great Sea Interconnector's value to Cyprus cannot be assessed from its headline capital contribution alone. A parametric accounting shows that the interconnector is likely to deliver a positive net consumer benefit across a wide and policy-relevant range of assumptions, particularly once the residual, netted nature of CBCA-based cost recovery is properly represented. Because the price-convergence benefit P_B itself blends both import- and export-side hours of market coupling, even the low-P_B, high-charge region of Table 1 should not be read as an unqualified net cost. It reflects a blended annual average that can still contain material export-side value for Cypriot generators exporting curtailment-prone renewable surplus.

Beyond this near-term consumer-cost question, the GSI's Cyprus–Israel segment and its integration into the IMEC framework point to a substantially larger strategic prize. Transforming Cyprus from Europe's last electrically isolated member state into a gateway node for renewable-electricity trade between South Asia, the Gulf, and the European internal market. Evaluating the project solely against this year's tariff impact, while ignoring energy security value and corridor option value, risks a systematic undervaluation of one of the most consequential energy-infrastructure decisions that Cyprus and its European partners will make this decade.

We therefore recommend that future GSI cost–benefit assessments report, at minimum, four separate and explicitly quantified benefit categories, wholesale price convergence, avoided reserve and redundancy cost, resilience value against correlated regional supply shocks and flexibility dimension differentiation relative to parallel battery-storage deployment, rather than compressing them into a single price-convergence term or a single capital-cost figure. Doing so would allow regulators, project promoters and the public to evaluate the GSI and comparable strategic interconnectors, on the full basis of their consumer, security, and corridor-positioning value, rather than on the narrow and frequently misleading question of headline cost alone.

Limitations of this work

The quantitative results presented are designed to clarify the mechanics and orders of magnitude that should inform public and regulatory debate, rather than to serve as a fully fledged investment-grade model. Several limitations follow directly from this choice:

- The parametric net-benefit analysis abstracts from detailed hourly dispatch and congestion patterns on the GSI and on the interconnected Greek/EU system. In practice, P_B, C_{GSI}, and C_R would be estimated from chronologically resolved simulations of market coupling, reserve procurement, and network constraints, using realistic load and generation profiles and incorporating stochastic variation in renewable output and outages. Our use of representative ranges for these parameters is therefore indicative rather than predictive.
- The analysis treats the GSI usage charge C_{GSI} as exogenous and static, whereas in reality it will depend on regulatory decisions regarding depreciation schedules, allowed rates of return, and volume-risk sharing, all of which may evolve over the project's life. Similarly, the reserve-cost term C_R is represented as a simple per-kilowatt-hour quantity, while real-world reserve requirements will vary with system topology, resource mix, and operational practice.
- Energy security value is discussed qualitatively and categorized into avoided reserve and redundancy cost and resilience against correlated shocks, but it is not monetized explicitly. A complete assessment would quantify these benefits using, for example, probabilistic risk analysis of fuel-supply disruption scenarios, estimates of the economic cost of unserved energy, and valuations of reduced curtailment of renewable generation.

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