A techno-economic and financial analysis of a GCC–India undersea electricity interconnector

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Key Messages

A techno-economic case for a Gulf Cooperation Council (GCC)–India interconnector is clear: an interconnector is part of the least-cost 'optimal' power system in 64 of the 75 scenarios studied.

The financial case for the GCC–India interconnector is less clear. Of the projections developed for the scenarios from the techno-economic model, only a small number are immediately investible.

There is strong need to identify policy/market conditions to encourage such 'system-optimal' investments that are seen as risky from an investor's perspective.

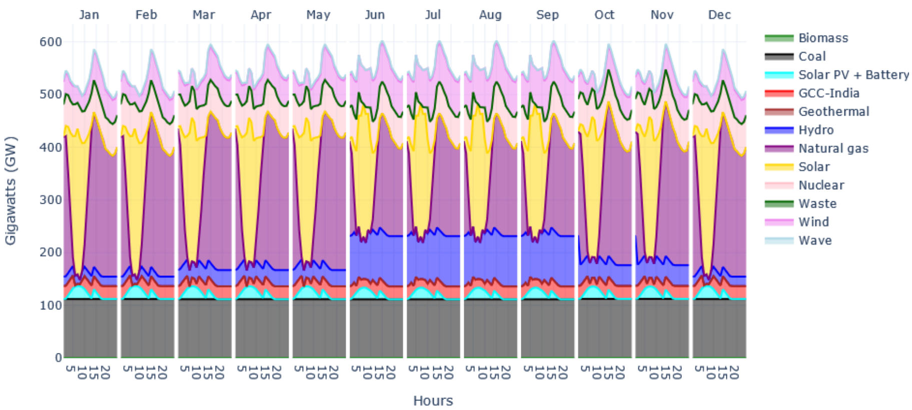

Figure 1: Hourly power generation for India in 2050 – monthly average (Primary x-axis: Hours [0–24]; Secondary x-axis: Months; Y-axis: Gigawatts [GW])

Introduction

Many large economies have now announced net zero target years. These include the UK [1], EU, and China [2]. The IEA recently suggested that a net zero target for the global energy system is now within reach [3]. The power sector will therefore have to cope both with increasingly electrified energy systems as well as higher shares of intermittent renewable generation capacity, such as wind and solar photovoltaics (PV), in the coming decades. One promising solution to this challenge is cross-border electricity interconnectors. By connecting geographically distributed renewable potentials to electricity demands across borders, supply–demand mismatches can be mitigated [4]. This briefing summarizes a techno-economic and financial analysis of installing a new interconnector between the six Gulf Cooperation Council (GCC) states, India, and South-East Asia. In the current version of the model, the maximum capacity of the interconnector is assumed to be 25 Gigawatts and can be built between 2028 and 2050. In addition, three potential sites for a solar PV farm that can be built together with the interconnector are considered. The analysis is based on a techno-economic model that aims to minimize the total costs of the GCC and India's electricity systems from the present until 2050. The model is subject to a set of constraints and policy considerations such as India's renewable energy deployment targets and the emission reduction goals set by GCC countries and India in their Nationally Determined Contributions (NDC) in the Paris Agreement.

Cross-border electricity trade flows through the GCC–India interconnector

The results of hourly bi-directional electricity trade flows for the years 2030, 2040, and 2050 are shown in **Figure 2**. The direction of trade flows is dominated by electricity from India to GCC in 2030. This pattern remains consistent across all months and for most hours. The exceptions are between 14:00–16:00 UTC (19:30–21:30 IST) in all months outside India's monsoon season. The time period coincides with the evening peak demand hours in India. During India's monsoon season, the trade flow is entirely in the direction towards the GCC. This coincides with the likely availability of surplus hydropower generation in India.

Electricity flows through the GCC–India interconnector in 2040 see a continuation of the earlier pattern of India->GCC dominating the direction of trade. However, in addition to evening peak demand hours in India, there is increased flow of electricity from GCC->India during the daytime peak demand hours of 07:00–11:00 UTC (or 12:30–16:30 IST). Maximum hourly electricity flow in the GCC->India direction increases to just under 10 GWh, while in the India->GCC direction it increases to 15 GWh.

By 2050 we see a reversal in the dominant direction of flow; electricity trade in the GCC->India direction now makes up a majority of total electricity trade volume. As India reaches its technical potential for renewable capacity expansion, electricity imports from the GCC–India interconnector represent a relatively low-cost alternative. While the seasonal pattern of trade flow from India->GCC remains, the flow in the opposite direction is consistently high throughout the year. The flow now bridges the daytime and evening peak hours, coinciding with both as well as the hours in between.

The model results highlight a somewhat counterintuitive trend; the magnitude of electricity flows is greater in the India->GCC direction than from GCC->India until 2050. The trend of use shifts in the other direction in 2050. This is likely due to the significant increase in electricity demand expected in India over the coming decades.

Figure 2: Hourly bi-directional trade volumes across the GCC–India interconnector in 2030, 2040, and 2050 (Primary x-axis: Hours [0-24]; Secondary x-axis: Months; Y-axis: Gigawatt-Hours [GWh])

Financial feasibility

In order to be aligned with the techno-economic model, the interconnector revenue is calculated using a time-of-use tariff based on the difference in marginal costs between the connection nodes on either side of the interconnector. This means that as the interconnector grows in capacity, this marginal difference becomes smaller and the interconnector's revenue stream becomes smaller. It is expected that the opportunity for arbitrage — taking advantage of a price difference between two or more markets – would be greater if the interconnector were to be constrained in size, thereby improving its case for investment.

Two types of discount rates are considered in this analysis: social discount rate and project discount rate. The former relates to how future benefits weigh up against the costs of action today. It considers costs and benefits on a society-wide (or system-wide in this case) basis. Project discount rate, on the other hand, relates to costs and benefits from the perspective of an investor in a specific project. In this analysis, a range of project discount rates for the interconnector are considered alongside a range of social discount rates.

The net-present-value (NPV) — a measure of the present value of a series of future cash flows — of the proposed interconnector project is shown in **Figure 3**. For almost all scenarios, the project NPV is negative. The strongest relationship is between NPV and interconnector (IC) unit cost. NPV decreases with increase in interconnector unit costs. The social discount rate also shows some relationships with the NPV of the interconnector. This could be because, at lower social discount rates, the penetration of renewables is higher, which increases the arbitrage opportunities across the interconnector.

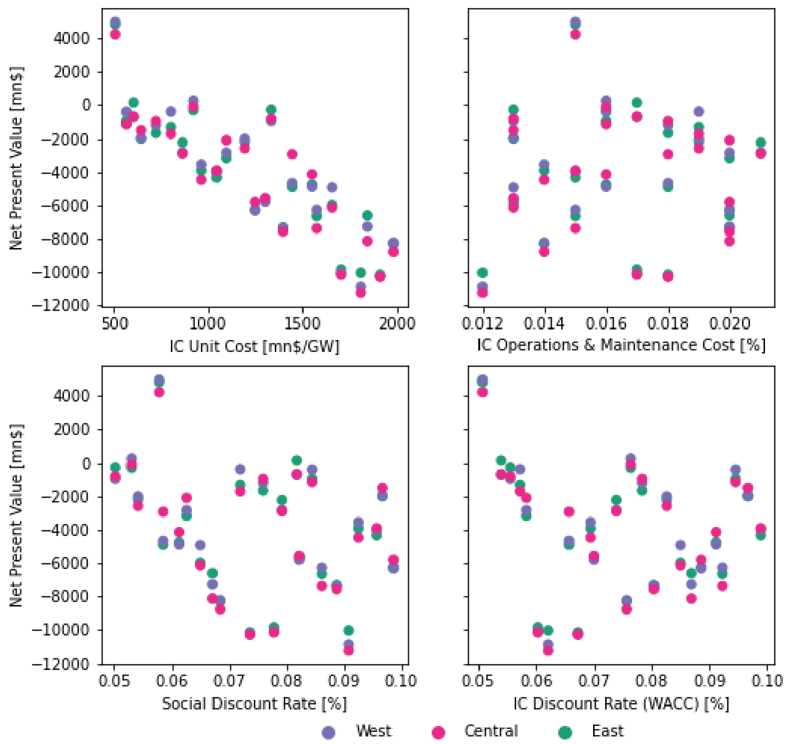

Figure 3: Project net present value dependence on scenario parameters

As the techno-economic model seeks to minimize total system costs, it will not necessarily choose capacities which allow for maximum profitability of the interconnector. As shown, in almost all scenarios, the maximum size available is chosen for the interconnector. This suggests that the presence of the interconnector substantially reduces total system costs, but the negative NPV shows that the interconnector itself is currently not capturing these benefits. In almost all scenarios, the returns on investment (shown as 'Project mIRR' and 'Equity mIRR' in **Figure 4)** are positive. If more of the benefit provided by the interconnector would be accrued by the interconnector itself (i.e., if its revenue were increased) or if it were able to secure concessional and government financing and grants which lowered its costs of capital sufficiently, then the interconnector would be investible as-is.

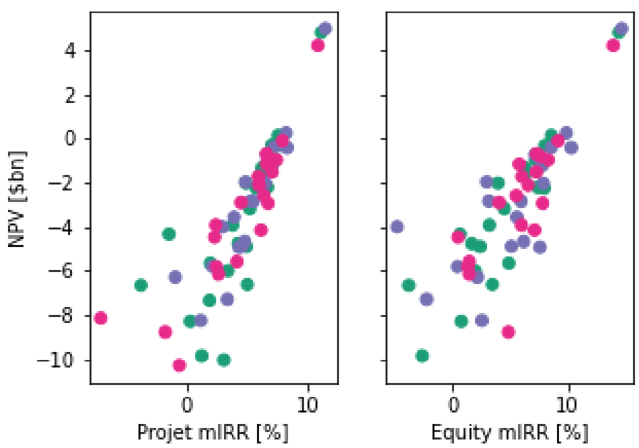

Figure 4: Relationship between Project and Equity mIRR and NPV

Conclusions and recommendations

This study provides an initial analysis of the GCC–India interconnector. **The techno-economic case for a GCC–India interconnector is clear: an interconnector is part of the least-cost 'optimal' power system in 64 of the 75 scenarios studied.** Bi-directional trade between the two regions can contribute towards reducing costs and emissions across a range of scenarios. The overall trade volumes are influenced by the location of the solar PV farm; locations further to the west contribute towards higher trade volumes in the GCC->India direction. Finally, the role of storage was found to complement rather than substitute the GCC–India interconnector, with both combining towards meeting India's peak load, as shown in **Figure 1**.

The financial case for the GCC–India interconnector is less clear. Of the projections developed for the scenarios from the techno-economic model, only a small number are immediately investible. However, the non-investible scenarios show a shortfall in investment attractiveness consistent with the difference between the techno-economic models and financial models.

Further expanding the geographic scope could help improve the overall feasibility of the GCC–India interconnector. For instance, the GCC is well-positioned to act as an electricity trading hub between Southeast Asia, India, and the African power pools (regional power grids and electricity markets). Another avenue for further exploration is to **identify policy/market conditions to encourage such 'system-optimal' investments that are risky from an investor's perspective**. For example, a price cap and floor arrangements underpinning such projects would help reduce the investment risks (and therefore the cost of capital). This finding highlights the role of concessional and government financing, which could improve the financial case for projects with a clear system-wide benefits.

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Notes

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