

Regional Energy Market Integration in South Asia with a Focus on vRE

A Planning Perspective

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Abstract — Efforts are underway to assess the way forward for integrating the South Asia Countries in a common energy market. To start, the focus would be on India, Bangladesh, Nepal, and Bhutan, since these countries are already connected to the Indian Power Grid, and also have diverse and complementary generation resources which could provide synergy in operations. In view of achieving the maximum economic and environmental benefits of integrating these countries as a common market, the planning process needs to be robust and all-inclusive, especially due to high Variable Renewable Energy (vRE), i.e. Wind and Solar, penetration expected in the region in the near future.

Any planning process intended to efficiently achieve the goal of regional market integration should start with the development of a comprehensive Regional Power Development Plan (RPDP), founded on the pillars of (i) determining the long-term generation requirements for the region and assessing the transmission and other related infrastructure requirements to support the regional operations, (ii) identification of the policy and regulatory provisions to govern the integrated market, (iii) formulating the payments and settlement methodology for the market participants under various categories, and (iv) facilitating in setting up Institutions responsible to carry out the market operations and settlements.

In line with the pillars of RPDP development, this paper provides an overview of the roadmap from a planning perspective for achieving the optimum benefit of integrating and operating the South Asia countries as a common energy market, starting with possible methods to design an integrated long-term generation plan considering the projections/requirements for each country, followed by the capacity assessment of intra-country and inter-country transmission lines to cater to the long-term market requirements.

A major focus area is to ensure that the RPDP is prepared in order to ensure that the maximum generation from vRE sources in the countries can be utilized, with sufficient conventional generation with necessary ramping capabilities is available to counter the variability of the vRE resources. To achieve this goal, this paper outlines a template of the RPDP preparation methodology, which needs to include aspects related to the generation capacity expansion planning over the long term to determine the capacity required to meet the demand at regional level as well as for individual country. The expansion planning provides inputs which would then be utilized in production simulations for individual countries and on a regional basis to determine the optimum operational methodology in terms of system costs. Another important analysis in this respect is regarding the system reliability in view of the high vRE penetration. Furthermore, the transmission capacity expansion requirements can also be ascertained through the same exercise on a regional operation basis, which would be in terms of the transient stability and/or frequency response analysis.

Keywords- Regional Energy Market, South Asia, vRE Integration, Capacity Expansion Planning, Production Simulations, System Reliability, Transmission Planning

I. NEED FOR REGIONAL INTEGRATION

Several efforts are underway in the region to assess the way forward for integrating the South Asia Countries in a common energy market. To start, the focus would be on India, Bangladesh, Nepal, and Bhutan, since these countries are already connected to the Indian Power Grid, and also have diverse and complementary generation resources which could provide synergy in operations. This is evident when the available resources in these countries are seen, with Bangladesh having high gas reserves, Nepal and Bhutan having a high hydro potential, and India being endowed with

all of the above resources in varying degrees with additional advantage of having very high wind and solar potential in the region (owing to its size).

Some of these initiatives are being undertaken through the South Asian Regional Initiative for Energy Integration (SARI/EI) program by USAID. This program has its imprints in the several areas related to the cross-border electricity trade in the South Asian region, viz. Policy Regulatory framework, Transmission Interconnections, Regional Power Market, etc. [1]

A. Benefits of Regional Integration

The need (or possible benefits) of the regional integration of South Asian countries in a common market can be categorized in the following categories:

1) Economic Benefits:

- a) *Avoiding costs of generation capacity otherwise required in case of isolated operations*
- b) *Improving/enabling access to electricity for the regional populace, in relatively shorter time-span*
- c) *Avoiding system disruptions*
- d) *Operational synergy in matching demand and supply*

e) *Social benefits such as job creation, living conditions upliftment, etc.*

f) *Better conditions for the industries to thrive*

g) *Promoting competition in the market, thereby incentivizing competitive pricing and leading to overall cost reduction over the long term*

2) Environmental Benefits

a) *Migration towards the regional market provides opportunity for more vRE in the system, by virtue of a larger balancing area available to the operators*

b) *Emission reductions in the region, owing to reduction in the use of fossil fuels*

B. SWOT Analysis of Regional Integration in South Asia

A brief SWOT Analysis of the Regional Energy Market Integration in South Asia is as provided below.

In view of achieving the maximum economic and environmental benefits of integrating these countries as a common market, the planning process needs to be robust and all-inclusive, especially due to high vRE penetration expected in the region in the near future.

TABLE I. SWOT FOR THE REGIONAL MARKET INTEGRATION

Strengths	Weakness
Very High vRE (wind and solar) potential in the region, ideal for the objective of sustainable development	Current lack of uniform regulatory and policy provisions in necessary detail to enable the regional operation of electricity market, universally acceptable to all stakeholders
Availability of the diverse and complementary resources spread across the region, enabling the easier balancing of the system on the regional basis	Some impediments in the development of transmission infrastructure in some areas necessary for evacuation of power (India-Sri Lanka, and hilly terrains of Nepal, Bhutan)
Power demand in the countries is expected to see a high rate of growth in the coming years, thereby cutting out the risk of plans having over-capacity	Absence of the centralized institutional structure to govern the regional power market operations, transaction settlements, and dispute resolution
Already established power trade happening in isolation (bilaterally) between Bangladesh, Bhutan, and Nepal with India, thereby providing a live template for analysis of issues	Lack of a harmonized long-term detailed plan for market development with clearly defined targets and timelines
Opportunities	Threats
Diverse resource availability provides good opportunity to balance the consumption over resources reducing dependency on a given form for all countries	Disagreements over the pricing of the electricity between the countries
Increasing demand growth is high enabling the planners the cushion to plan without the risk of significant over-generation capacity in the system in future	Insufficient improvement in the grid within any country, hindering their ability to benefit from the regionally operated market
Regional Integration would also help achieving an operational synergy in demand-supply matching, and could result in cost savings for participants in the event when the peak demand of one country might be met with cheaper generation available in the neighboring country rather than using one's own resources	Possibility of strains in country relations
Possible avenue to connect with ASEAN Grid (e.g. through Myanmar) in future after the South Asian Regional Market is fully functional and settled	

II. INTERNATIONAL EXPERIENCES IN REGIONAL INTEGRATION OF vRE

Since every region has its own specific requirements and pre-conditions to be met, it would not be possible to replicate every step of the process adopted for one region for every

other region. However, such analysis does provide pointers for the best practices which may be adopted while designing or implementing such comprehensive and long-term planning. There have been several regions in the world where this process has been undertaken (and as such all places differ vastly in terms of the area, grid-capacity, generation mix, etc.)

which can be referred to in order to learn the outcomes and plan for impediments.

One such recent study titled ‘Western Regional Electricity Cooperation and Strategic Infrastructure (RECSI) Study’ was commissioned by the Natural Resources Canada (NRCan) and conducted by a team led by GE Energy Consulting - General Electric International Inc. (GEII) with an objective of evaluating the most promising electricity infrastructure projects with the potential to transition to a sustainable non-emitting electricity generation portfolio, in the Western provinces (viz. British Columbia, Alberta, Saskatchewan, and Manitoba) and the North-west Territories in Canada. This study involved a system-wide impact evaluation and comparison of 25 electricity infrastructure projects, including transmission, generation, and energy storage projects.[2] This study involved simulating models of the power systems of the regions involved in GE-Multi Area Production Simulation (GE-MAPS) software and evaluating the impacts with respect to the key matrices (viz. the carbon emissions, the production costs for each region adjusted for the imports and exports happening for each region, and the investment costs for projects in each region). This analysis provided an indication of the most optimum projects which may be commissioned in the region.

Similarly, for the ASEAN Member States, a similar regional coordinated planning process is undertaken since 2003 and named as ‘The ASEAN Interconnection Masterplan Study (AIMS)’, providing the basis of the regional planning and integrated development of the ASEAN Power Grid. Further, the latest study on AIMS (AIMS II) was concluded in 2010. This is intended to provide the power utilities in the ASEAN countries to have a common platform and vision towards the evolution of a common power market in the ASEAN region, through development of regional goals in terms of generation capacity, inter-country transmission capacity, and also providing an indicator of the investments required at a high-level.

III. PILLARS OF PLANNING PROCESS

As mentioned earlier, any planning process intended to efficiently achieve the goal of regional market integration should start with the development of a comprehensive Regional Power Development Plan (RPDP), founded on the following key steps (referred to herein as the pillars planning process), illustrated in the following figure:

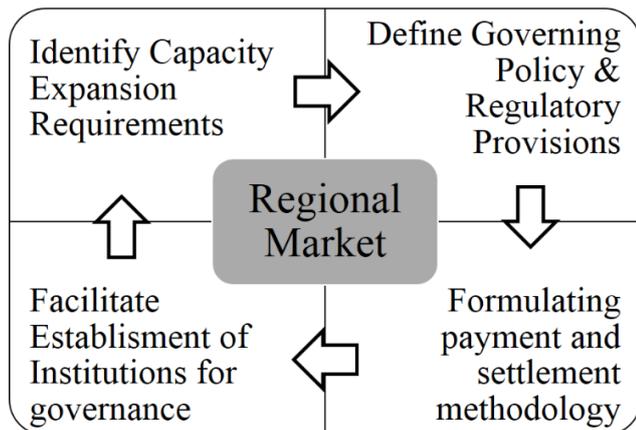


Figure 1. Steps for the Planning Process

(i) Determining the long-term generation requirements for the region and assessing the transmission and other related infrastructure requirements to support the regional operations – this step is the starting point for the development of an integrated RPDP, since ensuring long-term generation capacity adequacy is the foremost objective for such plans. For this purpose, a process adopted in other regions of the world is usually undertaking a Capacity Expansion Planning through modelling the expected demand projections, along with the current installed and under construction projects. The model also has, as an input, the candidate plants and/or transmission lines with their anticipated build costs in future. Apart from the above, other inputs related to the targeted planning horizon, current transmission interconnection capacity, reserve requirements, the operational profiles of the current installed generation capacity (both conventional and vRE) etc. are also utilized in the development of the model. The end-result of this process is that the model is expected to provide the optimum mix of future capacity to be installed/commissioned so as to meet the demand and reserve requirement targets for the country/region.

For the purpose of undertaking this analysis the most important factor is the data availability, since the accuracy of the models would be direct function of the extent of available data, its relevance to the requirements, and the congruence of the data available for different countries to enable a common model. Some of the important data requirements could be related to:

- Agreed Regional Planning horizon, and any country-level power development plans for future
- Peak Load (Demand) profiles – current and forecasted
- Generator/Unit data for the installed capacity
- Committed capacity additions in each country
- Targets for installed vRE Capacity
- Current and Future Transmission Capacity – inter-country (and intra-country if available)
- Operating Reserve Requirements for each country
- Current grid operational practices in each country (such as unit commitment and dispatch practices, frequency control, etc.)

The fidelity of the results would depend upon the quality of the data available for model preparation, and hence this step of the process should be initiated with concerted efforts of all concerned parties to ensure the best possible outcomes.

Another very pertinent consideration is to ensure that the sensitivity cases for the analysis are diligently selected and defined, so that the modelling results would have the maximum possible chance of providing a clear picture of the desired results. Again, these cases need to be decided based on the inputs from all concerned stakeholders, but in the larger view of the objective of the regional integration.

(ii) Identification of the policy and regulatory provisions to govern the integrated market – In the implementation of the large-scale integration and establishment of cross-border and multilateral electricity trading framework, there may be many barriers encountered on the regulatory front. These can range from issues arising out of the pricing structure adopted

for the vRE generation, and could also include issues related to their transmission, in view of the uncertainty and intermittency. It is, therefore, imperative to scrutinize and identify the current operational practices with each of the countries in the region, which would help in determining the areas where the practices are congruent and where they need to be updated to be brought in line with the best practices for regional operation. Thus, the objective here should be to take stock of the existing operational practices, recommend appropriate operational tools and approaches and develop a roadmap to reach the target.

As observed from similar global experiences, having the proper operating practices enables the system operator to balance the system under high RE penetration. However, unless requisite regulations or incentives are in place, the true effectiveness of the market cannot be ensured. Regulations in this context may also include grid codes that make vRE projects grid friendly and equips them with the capability to provide a service. Sufficient incentives are needed to ensure there are enough reasons for the participants to get involved in the market which would provide an impetus to kick-start the operations during at least the initial phases.

(iii) Formulating the payments and settlement methodology for the market participants under various categories – For the existence of a power market between various regions/countries, the pricing mechanisms in place to make such transactions should be made economically lucrative to a sufficient degree, which would provide an incentive to get the participation in the market from the stakeholders. As such, the pricing structure should also be cognizant of the fact that there are inherent risks involved in the market operations involving entities from different countries and should adopt the pricing taking these into account. Further, as the market evolve, it should be ensured that the pricing of electricity trade should be left to the market forces rather than have an excessively regulated structure in place to decide the pricing.

The settlement philosophy and structure should also be designed keeping in view the needs and requirements of participants from different countries which need to operate as per their respective market mechanisms. It is imperative that the settlement procedures be formulated keeping in view the need for providing sufficient security of receivables (which is electricity for buyers and money for the sellers), and balance that with a settlement period sufficient to cover the operational expenses of the participants. These, of course, would need to be designed for different market segments individually.

(iv) Facilitating in setting up Institutions responsible to carry out the market operations and settlements – The uniform institutional mechanism is also very important in the efficient operation of a system such as this, where many difference countries with different institutional and administrative models participate as a single entity. Having a uniform mechanism in place and a powerful authority to implement it would reduce the chances of conflict and disputes in the future and enable smooth market operations. In view of this, it is important to consider stakeholder recommendations on the possible management structure for the institutions proposed to be set up for the integrated regional market, and to accordingly decide on the universally acceptable provisions as a start.

It also needs to be known that the participants (especially Large Government Utilities) would prefer retaining control over the proceedings, and this could result in a conflict with the regional rules of operations. Therefore, the consultation process while designing the rules assumes even greater importance as it should ensure the legitimate concerns over operational practices are addressed.

In order to fully reap the benefits of synergies provided by an inter-connected regional power market, both in terms of vRE integration and conventional generation, it is imperative to have the different countries operate with a common objective. It is also paramount that there are robust and influential institutions set up to so that uniformity can be achieved in the operational practices between different countries along with an impartial and transparent system for handling of day-to-day issues during operations. The presence of impartial and powerful institutions is especially evident when the eventuality of a dispute arises and there is a need of its swift resolution at the earliest.

IV. PROBABLE WAY FORWARD FOR THE REGION

A robust and efficient power/electricity infrastructure is surely the backbone for creating a prospering economic and growth environment, evident from the different templates adopted by various other regions and countries around the world. In line with the pillars of RPDP development explained earlier, the possible way forward for the South Asian Region may be to now work towards developing the roadmap from a planning perspective for achieving the optimum benefit of integrating and operating the South Asia countries as a common energy market. This roadmap should have buy-in from all relevant stakeholders in the South Asian Region and should commence with exploring possible methods to design an integrated long-term generation plan considering the projections/requirements for each country, followed by the capacity assessment of intra-country and inter-country transmission lines to cater to the long-term market requirements.

However, a foremost consideration before initiating this process is with respect to the funding available for conducting such analysis along with the selection of the expert committee who would explore the necessary way forward. This is imperative since the Funding Agency should be an integral part of the whole process from the outset, to ensure that the steps of the process are aligned with the targeted objectives of this initiative and also to provide overall guidance to the teams conducting the analysis utilizing the various resources which may be available to them. As such, in studies involving multiple countries and stakeholder, it is usual to have multi-lateral funding agencies (such as the World Bank, USAID, ADB, GiZ etc.) involved in the process and funding the initiative.

A major focus area is to ensure that the RPDP is prepared in order to ensure that the maximum generation from vRE sources in the countries can be utilized, with sufficient conventional generation with necessary ramping capabilities is available to counter the variability of the vRE resources.

In view of the above, a template of the process which may be adopted for the development of a RPDP in the South Asia region (starting with the countries as identified at the start of this paper, viz. India, Bangladesh, Nepal, and Bhutan) can be

illustrated in the following figure and detailed in the description that follows:

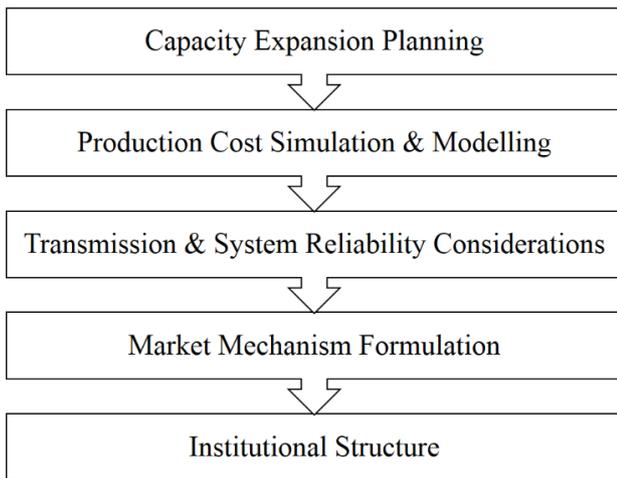


Figure 2. Template for RDPD Development Process in South-Asia

A. Capacity Expansion Planning

To achieve this goal, the initial process needs to include aspects related to the generation capacity expansion planning over the long term to determine the capacity required to meet the demand at regional level as well as for individual country. Electrical demand in a particular region is function of a number of parameters including population growth, industrial progress and commercial as well as economic activities in the region. The key criteria in the process of expansion planning is to ensure that the additions result in the most economic operating scenario which combines the operating cost and the capital cost required for the new additions while ensuring that the load is met with acceptable reliability levels. For regions such as South Asia this assumes an even bigger importance owing to fact that the demand growth is expected to be in the high ranges (when compared to other countries/regions), due to the both the size of the constituent countries as well as a large portion of the populace still not being connected to the grid or having access to electricity. This fact alone makes it imperative to have an integrated generation planning very critical to the success of the regional interconnection endeavor.

Furthermore, in the case of South-Asia (especially the countries of Bangladesh, India, Nepal and Bhutan), the availability of complementary resources for electricity generation makes it imperative to conduct such a collective capacity expansion planning process which would ensure that the capacity planned for the future is optimized both in terms of costs, as well as emission goals for the region while also ensuring that the region and countries demand is met. This would be a big task, in view of the complexity of the power systems of the countries in focus, however the pros associated with undertaking this step far outweigh the cons (effort required to build consensus, data assimilation, model preparation, costs for conducting the study, etc.).

B. Production Cost Simulations and Modelling

The expansion planning provides inputs which would then be utilized in production simulations for individual countries and on a regional basis to determine the optimum operational methodology in terms of system costs. This analysis is expected to provide an indicator of the economic

benefits which the regional cooperation offers towards maximizing the optimum utilization of the resources available within the power system.

Such simulations may be carried out under two scenarios, one where each country in the region is operating either stand-alone basis or with interconnections as per current plans, and another where there is full regional cooperation opportunity available for the countries to operate more flexibly utilizing the resources available in the region. The comparison of the results from the two scenarios would quantify the benefits of the operations at the regional level and would also indicate the benefits of having a larger balancing area while integrating the vRE resources in the system.

C. Transmission and System Reliability Considerations

Another important analysis in this respect is regarding the system reliability, in view of the high vRE penetration, which is one of the primary concerns for system operators. Power system operation relies on the forecasting of uncertain entities like Load (demand), Forced outages of power system elements (generators and transmission system), and intermittency and uncertainty associated with vRE generation which depends on the unpredictable natural resources like wind and sun. At planning level, reliability criteria can be fixed, and infrastructure can be strengthened with adequacy assessment studies. However, for systems with considerable RE penetration and larger load areas connected with interfaces, operational consideration of reliability is also important.

Furthermore, the transmission capacity expansion requirements can also be ascertained through the same exercise on a regional operation basis, which would be in terms of the transient stability and/or frequency response analysis. A Transmission System Analysis can be conducted for the South-Asia region, in order to review and identify the constraints for the power transfer between the countries, which could impede the successful implementation of the regional power market. This could include Power Flow Analysis, (n-1) Contingency Analysis. Stability analysis can also be conducted to assess stability issues like inter-area oscillations, maximum power transfer limits between the countries imposed due to stability issues etc. for the planned South-Asian Grid.

D. Market Mechanism Formulation

For all the above to become implemented, there needs to be a robust market mechanism in place which would enable transactions to be done smoothly between parties within the region. While it would take a while for full competition to become a reality in the regional market (mostly owing to the fact that markets in most countries in this region are still dominated by long-term PPAs), there is opportunity for defining the market processes and rules to enable the establishment of a regional market with some degree of competition.

The important points to consider in this regard is to prepare the common ground with regards to the parameters such as the transactional currency, the scheduling processes, market operation timelines, settlement duration and methodology, payment securities, and penalties. The development of these is required to be supported by the Regulatory Commissions in all the countries of the Region, to ensure these provisions are operationally aligned to the corresponding provisions in the countries.

E. Institutional Structure

Last but not the least, there needs to be a designated organizational set-up entrusted to carry out the market operations, governance, coordination, and empowered to address the grievances of the parties. Such an organizational set-up shall be having representation from all the participating countries in the market but needs to operate independently from the current structures present through the respective governmental hierarchies.

For a region like South Asia, where there is significant differences in the state of market development between countries, it may be considered that the initial steps could be led by adopting a two-pronged strategy, wherein the country with the most developed market (in terms of processes) leads the way in formulating the rules for setting up of the institutional structures governing the regional market, and the smaller countries have ample representation in such an institutional structure enabling them to gain sufficient experience from this process to implement in their respective countries also. This would allow the initial market establishment process to be robust, while also allowing a platform so that this process is not dominated by a single participant and ensures equitable terms of operations and governance.

Again, the actual institutions which emerge as a result of this process would need to be provided sufficient powers to effectively regulate, govern, operate, and adjudicate on matters pertaining to the regional markets.

ACKNOWLEDGMENT

The process and steps elaborated in this paper are based on the high-level understandings gained from similar efforts for integration in different regions. They therefore can serve as an indicator for the South-Asia region, but are not intended to provide a definitive way-forward for executing such an effort at any national or regional level. The views and opinions expressed in this paper are those of the authors and do not necessarily reflect the institutional views of General Electric Company. The authors and/or General Electric Company shall not be liable to claims of any nature arising as a result following the views expressed in this paper.

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