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

A Planning Perspective

September 5, 2019

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In this document, we sometimes use information derived from consolidated financial data but not presented in our financial statements prepared in accordance with U.S. generally accepted accounting principles (GAAP). Certain of these data are considered "non-GAAP financial measures" under the U.S. Securities and Exchange Commission rules. These non-GAAP financial measures supplement our GAAP disclosures and should not be considered an alternative to the GAAP measure. The reasons we use these non-GAAP financial measures and the reconciliations to their most directly comparable GAAP financial measures are posted to the investor relations section of our website at www.ge.com. [We use non-GAAP financial measures including the following:
• Operating earnings and EPS, which is earnings from continuing operations excluding non-service-related pension costs of our principal pension plans.
• GE Industrial operating & Verticals earnings and EPS, which is operating earnings of our industrial businesses and the GE Capital businesses that we expect to retain.
• GE Industrial & Verticals revenues, which is revenue of our industrial businesses and the GE Capital businesses that we expect to retain.
• Industrial segment organic revenue, which is the sum of revenue from all of our industrial segments less the effects of acquisitions/dispositions and currency exchange.
• Industrial segment organic operating profit, which is the sum of segment profit from all of our industrial segments less the effects of acquisitions/dispositions and currency exchange.
• Industrial cash flows from operating activities (Industrial CFOA), which is GE’s cash flow from operating activities excluding dividends received from GE Capital.
• Capital ending net investment (ENI), excluding liquidity, which is a measure we use to measure the size of our Capital segment.
• GE Capital Tier 1 Common ratio estimate is a ratio of equity]
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vRE: Variable Renewable Energy (wind and solar generation)
Benefits of Regional Integration in South Asia

**Economic Benefits**

a) **Avoiding costs of generation capacity** otherwise required in case of isolated operations

b) **Improving/enabling electricity access** 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, improvement in living conditions 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

**Environment 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
### SWOT Analysis for Regional Integration in South Asia

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weakness</th>
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</thead>
<tbody>
<tr>
<td>Very High vRE (wind and solar) potential in the region, ideal for the objective of sustainable development</td>
<td>Current lack of regulatory and policy provisions in necessary detail to enable the regional operation of electricity market, universally acceptable to all stakeholders</td>
</tr>
<tr>
<td>Availability of the diverse and complementary resources spread across the region, enabling the easier balancing of the system on the regional basis</td>
<td>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)</td>
</tr>
<tr>
<td>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</td>
<td>Absence of the centralized institutional structure to govern the regional power market operations, transaction settlements, and dispute resolution</td>
</tr>
<tr>
<td>Already established power trade happening in isolation (bilaterally) between Bangladesh, Bhutan, and Nepal with India, thereby providing a live template for analysis of issues</td>
<td>Lack of a harmonized long-term detailed plan for market development with clearly defined targets and timelines</td>
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<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diverse resource availability provides good opportunity to balance the consumption over resources reducing dependency on a given form for all countries</td>
<td>Disagreements over the pricing of the electricity between the countries</td>
</tr>
<tr>
<td>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</td>
<td>Insufficient improvement in the grid within any country, hindering their ability to benefit from the regionally operated market</td>
</tr>
<tr>
<td>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</td>
<td>Possibility of strains in country relations</td>
</tr>
<tr>
<td>Possible avenue to connect with ASEAN Grid (through Myanmar) in future after the South Asian Regional Market is fully functional and settled</td>
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International Experiences

Western Regional Electricity Cooperation and Strategic Infrastructure (RECSI) Study

- System-wide impact evaluation and comparison of 25 electricity infrastructure projects, including transmission, generation, and energy storage projects, in the Western Canadian provinces (technical advisory members included BC Hydro, AESO, SaskPower, Manitoba Hydro, and Northwest Territories).
- Among the projects/scenarios evaluated were:
  a) grid-scale compressed air energy storage (CAES) systems in Alberta, and
  b) grid-scale battery energy storage systems (BSEE) in Saskatchewan.
- Metrics evaluated were system-wide cost, operations, and emissions impacts.

ASEAN Interconnection Masterplan Study(s) (AIMS)

- For the ASEAN Member States, a similar regional coordinated planning process is undertaken since 2003 and named as ‘The ASEAN Interconnection Masterplan Study (AIMS)’
- These studies provide the basis of the regional planning and integrated development of the ASEAN Power Grid.
- The study proposed a comprehensive plan of regional transmission network that links ASEAN power systems.
- Recent focus on providing the power utilities in ASEAN to have a common vision towards the evolution of an integrated power market in the, 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 to accomplish the same.

# Regional Electricity Cooperation and Strategic Infrastructure Initiative (RECSI) information and report available on Alberta Electric System Operator (AESO)

* ASEAN Centre for Energy website (http://www.aseanenergy.org/)
Pillars of Planning Process

- **Identify Capacity Expansion Requirements**
  - Determining the long-term generation requirements for the region and assessing the transmission and other related infrastructure requirements to support the regional operations.

- **Define Governing Policy & Regulatory Provisions**
  - Identification of the policy and regulatory provisions to govern the integrated market.

- **Regional Market**
  - Facilitating in setting up Institutions responsible to carry out the market operations and settlements.

- **Formulating payment and settlement methodology**
  - Formulating the payments and settlement methodology for the market participants under various categories.
## Development of a Regional Power Development Plan (RPDP)

**Capacity Expansion**

- Initial step, **ensuring long-term capacity adequacy**

- Integrated Capacity Expansion planning through **modelling scenarios**

- The end-result expected from the model is the **optimum mix of future capacity** to be installed to meet the demand/reserve targets for the Country(s) as well as the Region

**Policy/Regulatory Provisions**

- To counter the **barriers in implementation** of the large-scale integration and **establishment** of cross-border and multilateral electricity trading framework

- Objective should be to take stock of the existing operational practices, recommend appropriate operational tools and approaches and develop roadmap

- Ensure sufficient incentives for participants

**Payments & Settlements**

- To be formulated to ensure **compelling lucrativeness** is present

- Cognizant of the fact that there are inherent risks involved in the market operations at this level

- Settlement procedures balancing the need for providing **sufficient security of receivables**

- Settlement period sufficient to cover the operational expenses of the participants

**Institutional Structure**

- **Uniform institutional mechanism** to ensure efficient operation of a system such as this

- **Empowered authority(s)** to oversee operations reduces the chances of conflict and disputes in the future

- Along with the universally acceptable policy and regulatory framework, should ensure competition along with the compliance

- Stakeholder buy-in
Probable Way Forward for South Asia Region *(starting with BBIN)*

- Designing a robust and efficient power/electricity infrastructure → backbone for creating a prospering economic and growth environment

- In line with the **templates adopted in studies of similar nature world-wide**, efforts may be undertaken to commission comprehensive analysis for the regional integration in South Asia starting with BBIN

- Such efforts targeted towards **developing the roadmap from a planning perspective** for achieving the optimum benefit of integrating and operating as a common energy market

- The funding and execution onus are the pre-requisites for conceiving such an analysis, and can be taken by through stakeholder consultations

**The possible components of the roadmap may be:**

- Capacity Expansion Planning
- Production Cost Simulation & Modelling
- Transmission & System Reliability Considerations
- Market Mechanism Formulation
- Institutional Structure
## Possible Template for RPDP Development Process

### Capacity Expansion Planning

- Determining the capacity required to meet the demand at regional level as well as for individual country
- Key criteria here is **ensuring 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)
- The demand growth is expected to be in the high ranges (when compared to other countries/regions)
- The availability of complementary resources for electricity generation makes it imperative
- This is a big ask in view of the complexities of the power systems of the countries in focus, however the pros far outweigh the cons

### Production Cost Simulation & Modelling

- Results of Capacity Expansion Planning utilized in production simulations for individual countries and on a regional basis to determine the **optimum operation** in terms of system costs
- This analysis is expected to provide an indicator of the economic benefits which the regional cooperation offers by optimum utilization of the available resources in the Region
- Simulations may be undertaken in two scenarios, where countries operate on **stand-alone basis versus integrated operations** on regional level
- Comparison of results from the two scenarios would quantify benefits derived from
  - the operations at the regional level and
  - having a larger balancing area while integrating the vRE resources in the system
### Transmission & System Reliability Considerations

- Ensuring system reliability assumes even greater importance in case of systems with high vRE penetration
- At planning level, reliability criteria can be fixed, and infrastructure can be strengthened with adequacy assessment studies
- The transmission capacity expansion requirements can also be ascertained through the same exercise on a regional operation basis
- Transmission System Analysis conducted to **review and identify the constraints for the power transfer** between the countries (Power Flow and (n-1) Contingency Analysis)
- Stability analysis conducted to assess stability issues like inter-area oscillations, maximum power transfer limits between the countries imposed due to stability issues etc. for the targeted South-Asian Grid

### Market Mechanism Formulation

- Robust market mechanism in place to enable smooth transactions
- Although, it may take a while for full competition to become a reality in the regional market
- Still, there's opportunity for defining the market processes and rules to enable the establishment of a regional market with some degree of competition
- Important point 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 above need to be supported by appropriate regulatory provisions
Possible Template for RPDP Development Process (contd.)

Institutional Structure

- There needs to be a designated organizational set-up entrusted to carry out market operations, governance, coordination, and empowered to address the grievances of the parties.
- Set-up with representation from all participating countries in the market, but needs to operate independently.
- Initial steps could be led by adopting a strategy of having the Country with most developed market to lead the way with representation from others.
- This would allow the initial market establishment process to be robust, while ensuring equitable terms of operations and governance.
- Sufficient legal and quasi-judicial powers to be accorded to the resulting institutions for successful regional operations.
About GE Energy Consulting

**Systems engineers & economists – Solving Tough Challenges & Delivering Customer Value**

**Services**
- **Power Economics**
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  - Energy financial analytics
- **Power Systems Operations & Planning**
  - Transmission and Distribution studies
  - Equipment applications
  - Renewables
- **Generation Products & Services**
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  - Specialty Hardware, Protection & Control

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- **Compliant and reliable from concept to engineered design**
- **Project life-cycle testing and compliance**

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- **MAPS**
- **MARS**

**Concorda** Software Suite

**TAILORED Power Systems and Energy Course**: Longest running energy executive development program
About GE Energy Consulting: Highlights

**US & Canada**
- Several renewable integration studies, totaling 100+ GW

**Barbados**
- Barbados Light & Power Renewable Integration Study

**India**
- Integrated wind, solar, and energy storage Study (USTDA)
- RE Modelling Study for Shakti Foundation

**Europe**
- Economic grid support from variable renewables

**Vietnam**
- Wind grid-code development and renewable integration study

**Evaluation of Sustainable Energy Options for the Big Island**
- 2008

**Oahu Wind Integration & Transmission Study (OWITS)**
- 2009

**Oahu-Maui Interconnection Study (Stage 2)**
- 2010

**Hawaii Solar Integration Study (HSIS)**
- 2011

**Oahu Distributed PV Grid Stability Study**
- 2012

**Oahu Battery Storage Study**
- 2013

**Hawaii RPS Study**
- 2014

**India (USTDA) Study**
- 2015

**India (Shakti) Study**
- 2016

**Hawaii DER Grid Services Study**
- 2017

**Barbados Light & Power Renewable Integration Study**
- 2018

**US & Canada**
- Several renewable integration studies, totaling 100+ GW
About Authors

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