



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

A Planning Perspective

September 5, 2019

Suramya Dwivedi

Senior Engineer – Power Economics
GE Energy Consulting - Bengaluru

Dr. Ravi Segal

Business Leader – South Asia, ASEAN, China
GE Energy Consulting - Bengaluru

Arun Kumar Unni

Manager – Power Economics
GE Energy Consulting - Bengaluru

2nd INTERNATIONAL CONFERENCE ON

Large-Scale Grid Integration of
Renewable Energy in India



4 - 6 Sept 2019
New Delhi/India

ENDORSED BY:





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

A Planning Perspective

September 5, 2019

Confidential. Not to be copied, reproduced, or distributed without prior approval.

CAUTION CONCERNING FORWARD-LOOKING STATEMENTS:

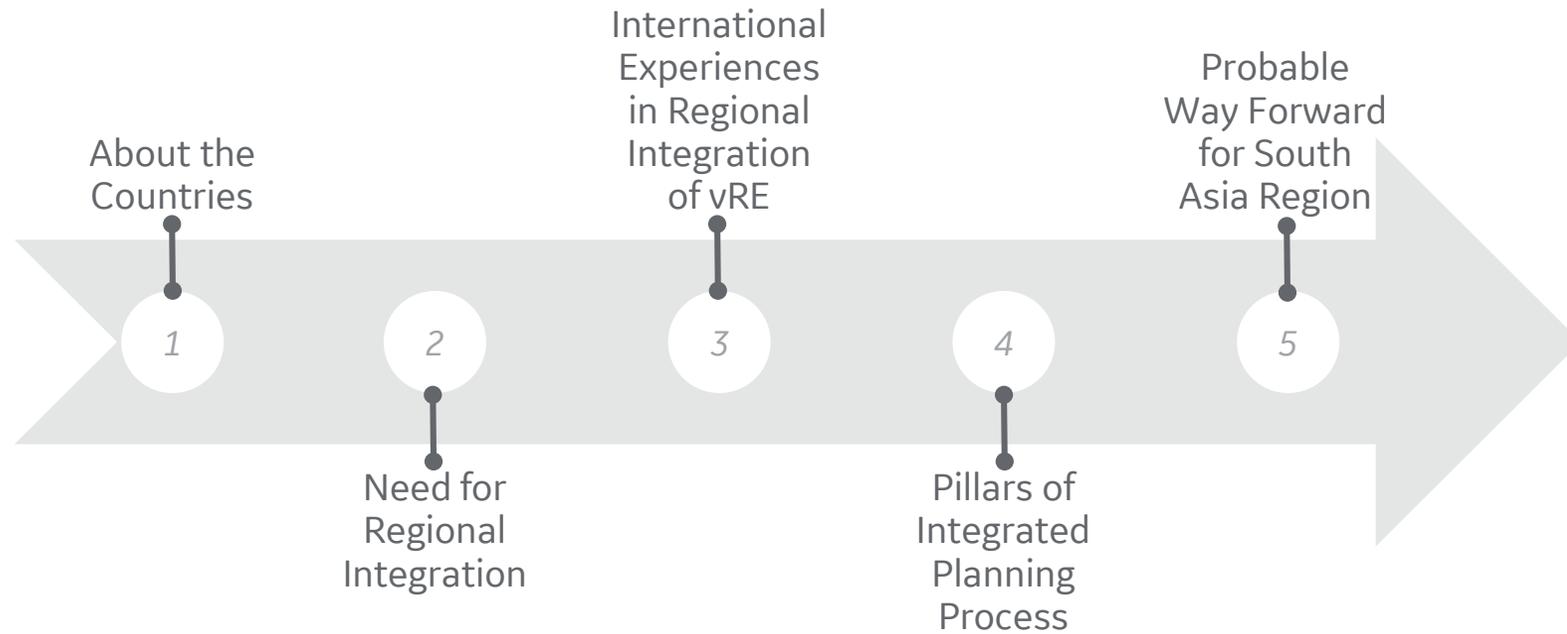
This document contains "forward-looking statements" – that is, statements related to future events that by their nature address matters that are, to different degrees, uncertain. For details on the uncertainties that may cause our actual future results to be materially different than those expressed in our forward-looking statements, see <http://www.ge.com/investor-relations/disclaimer-caution-concerning-forwardlooking-statements> as well as our annual reports on Form 10-K and quarterly reports on Form 10-Q. We do not undertake to update our forward-looking statements. This document also includes certain forward-looking projected financial information that is based on current estimates and forecasts. Actual results could differ materially. to total risk-weighted assets.]

NON-GAAP FINANCIAL MEASURES:

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

Contents



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

Strengths	Weakness
Very High vRE (wind and solar) potential in the region, ideal for the objective of sustainable development	Current lack of 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 (through Myanmar) in future after the South Asian Regional Market is fully functional and settled	



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.

[#] Regional Electricity Cooperation and Strategic Infrastructure Initiative (RECSI) information and report available on Alberta Electric System Operator (AESO)
<https://www.aeso.ca/market/market-updates/regional-electricity-cooperation-and-strategic-infrastructure-initiative-recsi/>

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. region

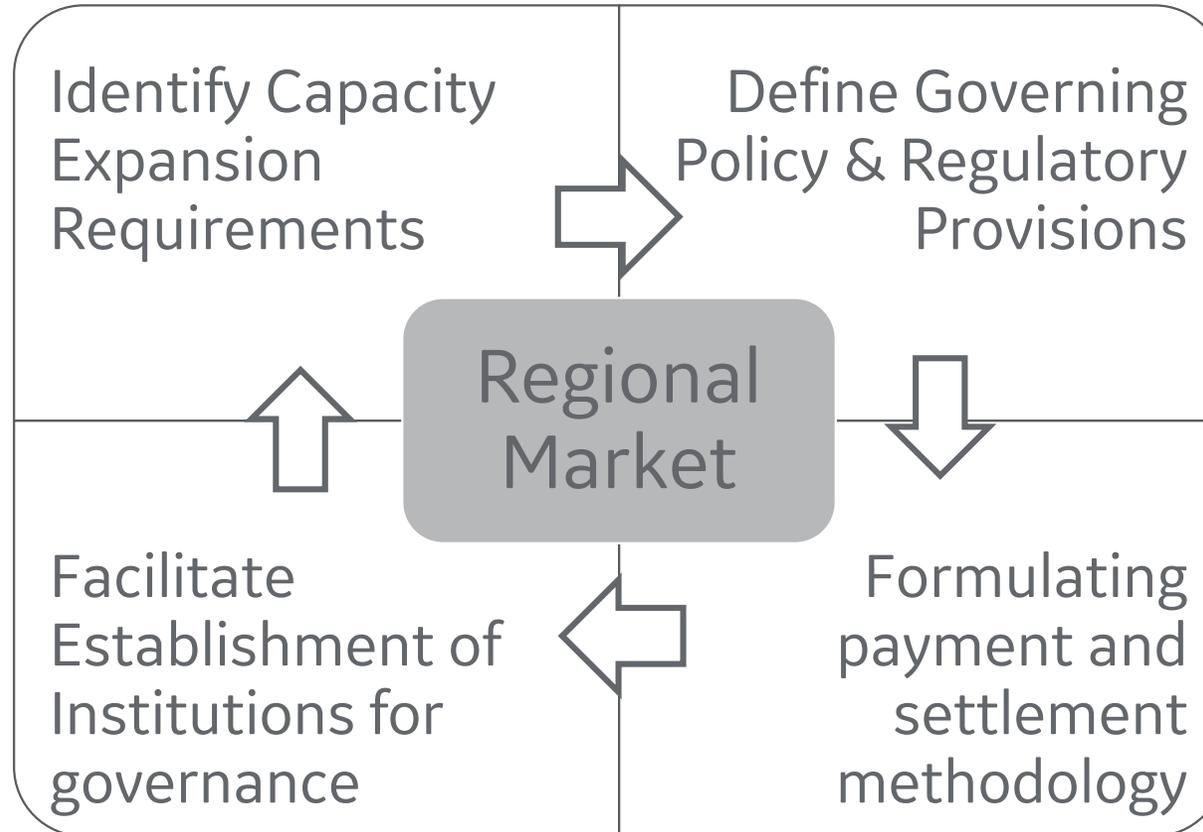
^{*} ASEAN Centre for Energy website (<http://www.aseanenergy.org/>)



Pillars of Planning Process

Determining the long-term generation requirements for the region and assessing the transmission and other related infrastructure requirements to support the regional operations

Identification of the policy and regulatory provisions to govern the integrated market



Facilitating in setting up Institutions responsible to carry out the market operations and settlements

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

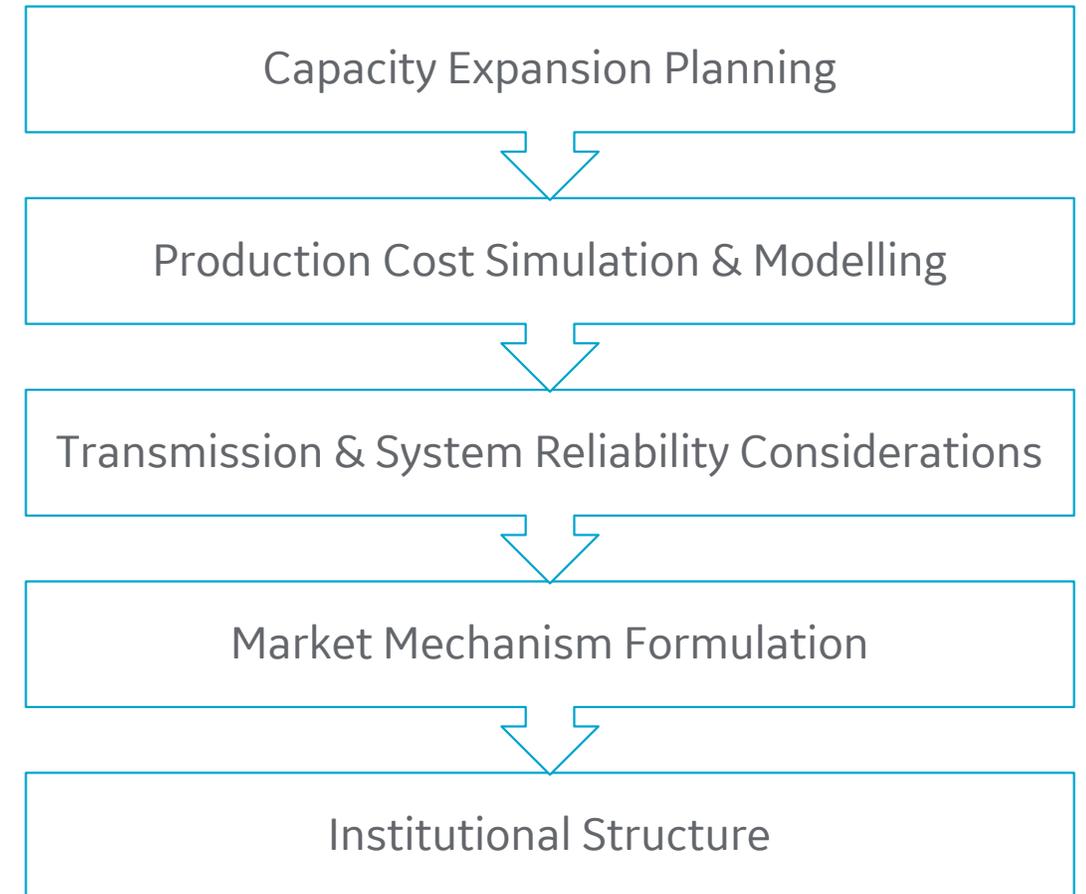
- ✓ **Uniform institutional mechanism** to ensure efficient operation of a system such as this
- ✓ **Empowered authority(s)** to oversee operations reduces the chances of conflict and disputes in the future
- ✓ Along with the universally acceptable policy and regulatory framework, should ensure competition 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:



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



Possible Template for RPDP Development Process *(contd.)*

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

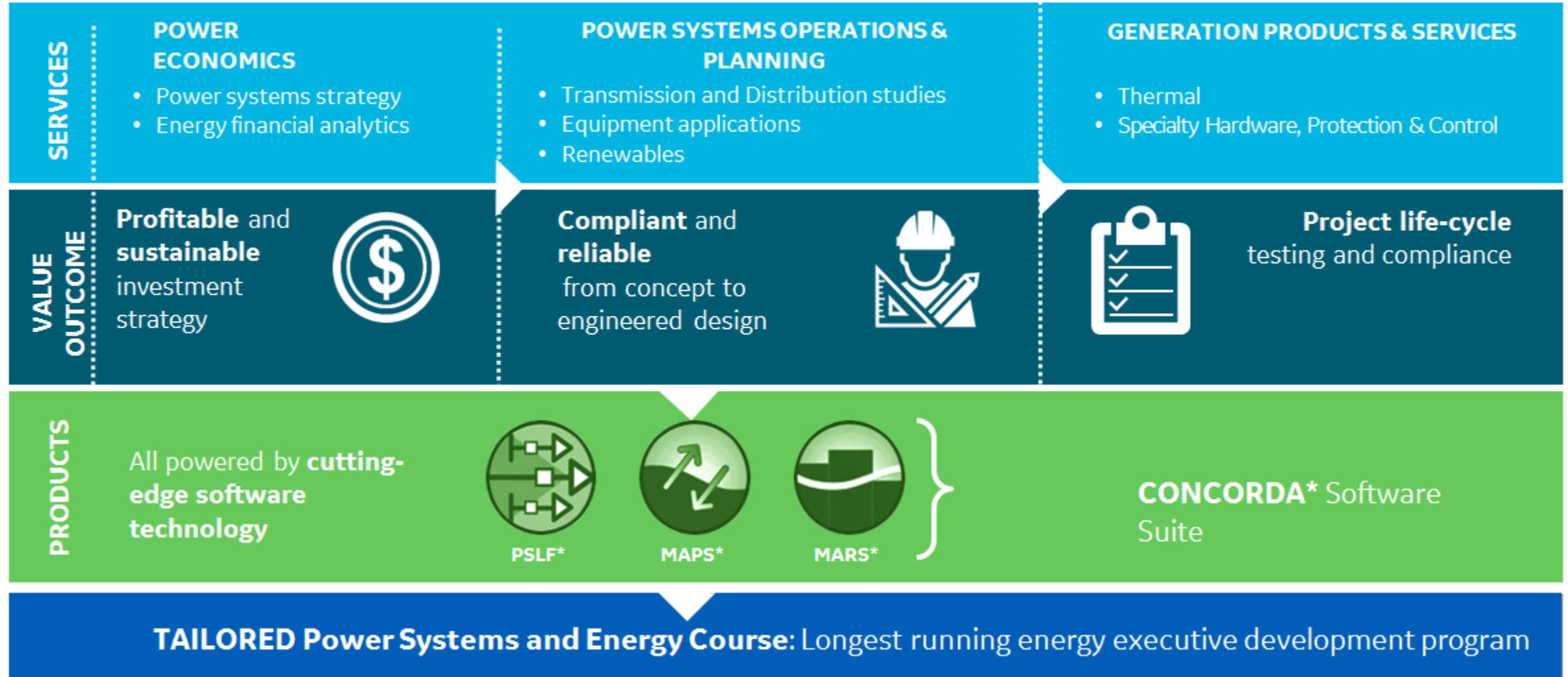
- There needs to be a **designated organizational set-up** entrusted to carry out market operations, governance, coordination, and empowered to address the grievances of the parties
- Set-up with representation from all participating countries in the market, but **needs to operate independently**
- Initial 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



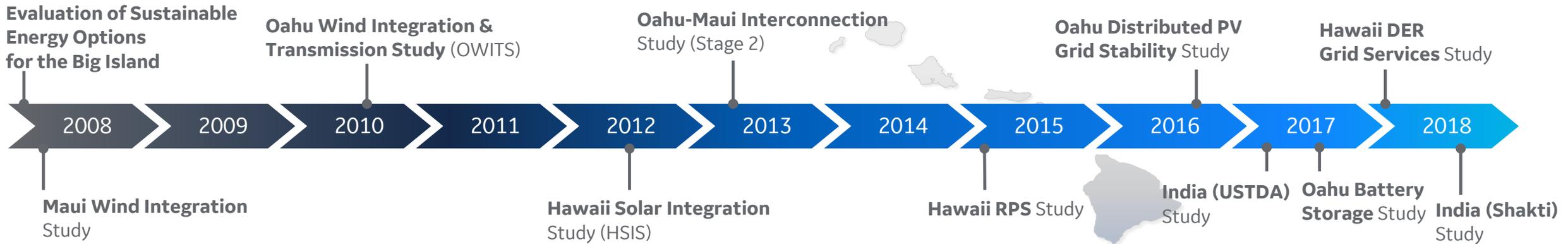
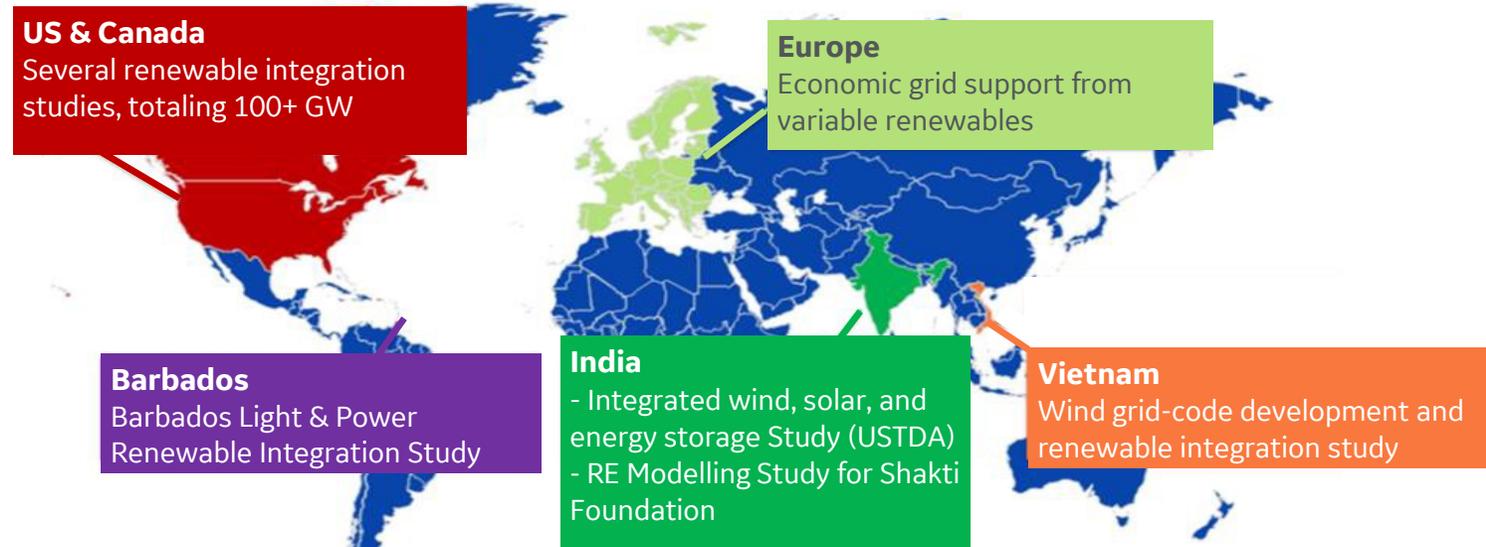


About GE Energy Consulting

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



About GE Energy Consulting: Highlights



About Authors



Mr. Suramya Dwivedi (Senior Engineer – Power Economics) | GE Energy Consulting | E-mail:- suramya.dwivedi@ge.com | Phone:- (+91) 98994 88951

Mr. Dwivedi holds B.E. (electrical engineering) from the G.G.I.T.S. Jabalpur, Madhya Pradesh (India) and M.B.A. (power management) from National Power Training Institute, Faridabad, Haryana (India). He has 10 years of experience in the Power Sector, and joined the Power Economics team of GE Energy Consulting in 2016. He is focused on development, application and direct use of detailed market models for the energy industry in support of delivering customer solutions and evaluating impacts of structural changes in electricity markets.

His main areas of work include projects pertaining to RE integration, power-market design, regulatory and policy analysis, and tariff modelling, specifically in India and South-East Asia. Mr. Dwivedi leverages his expertise with power markets in support of projects intended to determine how the increasing use of renewable energy affects both system operation and diverse types of power-generation technologies; to assess the reserve margin and ancillary services requirements for balancing the increased vRE share in the system; and advise on potential plant operational strategies for optimum resource utilization. Prior to joining GE, he was employed for 5 years with PTC India Limited.



Dr. Ravi Segal (Business Leader – South Asia, ASEAN, and China) | GE Energy Consulting | E-mail:- ravi.segal@ge.com | Phone:- (+91) 80 4930 8383

Dr. Segal has been leading the GE Energy Consulting group in India since 2008, operating out of Bengaluru, Karnataka, India. Dr. Segal holds B.E. and M.E. in electrical engineering from Punjab Engineering College and Ph.D. from IIT, Delhi.

He specializes in excitation system, speed control systems, testing of generators and other power plant related electrical & control system retrofits for Gas, Steam, Hydro, Nuclear and Industrial project power plants. He has conducted various technical training programs for customers. He is a Certified Six-Sigma Black Belt and has conducted several Six-Sigma training programs, as well. Prior to joining GE, he worked from 1985 to 1996 for Bharat Heavy Electricals Limited (BHEL).

Dr. Segal is a Senior Member of IEEE, life member of Institution of Engineers, a chartered engineer and has authored 14 technical papers. Dr. Segal is a member of IEEE task force committee to develop technical standards on Low Voltage DC (LVDC) for homes. Dr. Segal received TATA RAO Medal for a paper published in journal of Institution of Engineers (India).



Arun Kumar Unni (Manager – Power Economics) | GE Energy Consulting | E-mail:- arun.unni@ge.com | Phone:- (+91) 80 4930 8382

Mr. Unni leads the Power Economics team of GE Energy Consulting in India. Mr. Unni holds B.E. (electronics & instrumentation) from the Delhi Institute of Technology, and completed the advanced Management program from IIM Bangalore.

He joined the Power Economics team of GE Energy Consulting in 2008. He specializes in feasibility studies, financial modeling, and regulatory aspects of power generation markets, and has contributed to feasibility studies and tariff modeling for thermal, nuclear and renewable power projects. Mr. Unni has also led consultancy studies covering power demand projection, generation & transmission planning and production simulation, power market design. Prior to joining GE, he was employed for 12 years by the Reliance group of companies.

Mr. Unni is a University Gold Medalist (Delhi University) during his BE (Electrical, Instrumentation and Control Engineering). He has co-authored 5 papers published recently in several conferences.

