Pioneering smart grids for Indonesia – the case of a smart grid roadmap development

ISSN 2515-0855
doi: 10.1049/oap-cired.2017.0318
www.ietdl.org

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Abstract: Southeast Asia's power systems face huge challenges – from reliability issues, over steeply growing energy demands to questions related to the change in the generation and demand matrix. In addition to these challenges, plans to integrate large amounts of intermittent renewable energy sources are put forward. Last but not least providing energy access for all citizens remains a challenge for many parts of the region. Smart-grid technologies can facilitate solutions for demand growth, energy access and renewable integration. This study presents the establishment of a smart grid roadmap for Indonesia's power system including a discussion on the applied method. Experiences and lessons learned are condensed to 10 key questions that utilities should be able to answer, when starting an energy transition programme. The presented method and insights can be helpful not only for Southeast Asia but also for any utility that aims to leverage smart grid technologies in an optimised way.

1 Introduction: the project idea – a successful development aid-private sector initiative between GIZ ASEAN-RESP and Siemens on smart grids

In the framework of the joint cooperation between the Heads of ASEAN Power Utilities/Authorities (HAPUA) and the Renewable Energy Support Programme for ASEAN (ASEAN-RESP), GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH) and Siemens AG have teamed up to promote the utilisation of smart grid (SG) technologies in ASEAN with the aim to support the region's growing energy demand and implementation of renewable energies to cope with future grid challenges and adapting it to the local context [1]. The parties believed in SGs as a facilitator for a sustainable and economical development of Southeast Asia. In the approach SG technologies will be used to prepare grids for massive growth of demand, rapid expansion and integration of large amounts of renewable. The infrastructure will then build the backbone of sustainable growth [2]. This activity is outlined in the cooperation agreement between HAPUA/ASEAN Centre for Energy and ASEAN-RESP, under the third thematic area on Strategy in integrating variable renewable energy into power systems.

ASEAN-RESP and Siemens have executed workshops in which the concept of smart grids was presented to the utilities in the region. Siemens has developed a structured method, the Smart Grid Compass® Method that encompasses a 360° view on the needs and necessities of specific utilities with respect to smart grids [3, 4]. It allows the tailoring of the general smart grid concept to the implementation in a national environment, avoiding over-investments or ill-structured smart grid approaches. The Smart Grid Compass Method systematically identifies synergies by systematically evaluating all major utility processes to overcome barriers of distributed benefits among different stakeholders such as various departments or companies [5].

As part of the concept, ASEAN-RESP and Siemens launched a competition funded by GIZ and accessible to all ASEAN Utilities for the first phase of the Siemens Smart Grid Compass® consultancy. The competition was won by the Indonesian government-owned electricity company PLN (Perusahaan Listrik Negara) after an in-depth evaluation of PLN's initial concept and approach by ASEAN-RESP and Siemens.

To launch the development of a smart grid roadmap for Indonesia, the first phase of the Siemens Smart Grid Compass® – 'Orientation' – was executed with a joint PLN–Siemens workshop in Makassar, Indonesia, under patronage of GIZ. This paper presents the method and direct experiences as well as the lessons learned from setting up a smart grid roadmap for Indonesia and deriving lessons learned for the HAPUA Utilities.

2 Pioneering smart grids and coming from pilots to robust and replicable systems

PLN has actively been promoting and pioneering smart grids in the form of technology pilots since a couple of years. The aim of the Corporate Planning Directorate of PLN for the described project was to create a consistent roadmap for PLN that would cover all aspects of PLN's smart grid activities, overcoming short-views notions such as 'smart grids are only for renewables' or 'smart grids are luxury and only necessary in well-developed countries'. Instead, PLN needed a powerful approach in which the company could look in a structured way at suitable technologies and decide on their applicability, their impact on increasing the process efficiency of PLN, and the enhancement of the reliability of the Indonesian Power Grid.

2.1 Supplying 250Mio+ with access to electricity and power in a growing economy is a challenge

Indonesia, with a population of over 250 million, is the fourth largest population in the world. Its population is expected to grow to more than 300 million within the coming 15 years. Combined with the outlook of economic growth and an improved standard of living, this leads to a heavy increase in energy demands. To meet the growing demand, Indonesia has to more than double its generation capacity, upgrade its transmission and distribution system and revolutionise the system operation. Electric transmission and distribution systems are already operated close to their absolute limits with respect to the static limits in terms of transport and distribution capacity, short-circuit capacity and the dynamic stability limits of the system.

Frequent power outages and low service reliability are some of PLN's existing challenges and are of course different from region to region. Without decisive action, these challenges will get even more serious, specifically for the Java–Bali System that is already prone to outages due to network constraints and dynamical effects in the network.

An additional challenge is to bring energy access to all of its population considering the country's specific geographic situation with their population spreading over more than 5000 islands. Striving for universal energy access is a typical driver of renewable energies and will further increase the need of smart grid concepts [6]. To effectively and efficiently tackle these challenges, Indonesia will require tremendous grid extensions. All those extensions and upgrades have to be managed under budgetary constraints and therefore need careful shaping. In order to do so, PLN's operations require a boost in efficiency and effectiveness. These modernisations should be planned and coordinated in an optimised way. With a professional implementation of smart grids latest technological developments and best practice processes can be leveraged. Nevertheless, they need to be tailored to the Indonesian context, taking into account specific requirements to meet the country's energy vision. Only with a structured approach, these tremendous challenges can be successfully mastered.

3 The 10 key questions for smart grid planning

When setting up programmes for the implementation of smart grids, there are numerous questions to be answered ranging from high-level aspects of a country's or grid operator's vision over budget requirements to specific design options and technology implementations [2, 7]. Together with Siemens, PLN addressed many of these questions, identified the answers and developed a good understanding on how to answer outstanding issues and leveraging smart grid technologies in an optimised way.

These questions can be condensed to 10 key questions, which the authors found interesting, not only for PLN but also for any utility addressing smart grids and renewable energy.

3.1 How do we break down our vision into measurable objectives?

The potential benefits of smart grids are manifold: From improving service reliability and quality, over reducing (non-)technical losses, to improving work process efficiency and many more. Boundary conditions (e.g. policies, regulation, customer requirements, culture, and available energy resources) are utility specific. Thus, it is important for every utility company to have a clear and aligned view of their main priorities and objectives to optimise a smart grid implementation programme.

3.2 How do we link our company's vision with our daily work?

Every employee should know how her daily work and the processes she executes support her organisation's vision. Introducing a smart grid concept changes an organisation's DNA, thus, its processes and required infrastructure. During such a transformation it is even more important to exactly understand how these changes influence key objectives and how they are interconnected with each other. This allows designing a smart grid implementation programme, which develops processes and the technological infrastructure in an optimised way.

3.3 How to develop a positive and reliable business case?

It is often difficult to find positive business cases, when focusing on only one specific problem or objective to be tackled by smart grid technologies. However, most of the time there are many potential benefits distributed over various departments and even other entities, which could be positively affected by the use of smart grid technologies [5]. Thus, the process of finding and leveraging synergies between diverse processes utilising technology and investments has become a key success factor for smart grid implementation programmes.

3.4 How to increase system reliability, efficiency and power quality?

Besides expensive traditional measures (more copper), there are auspicious smart grid approaches (more intelligence). The current paradigm shift (from controllable generation towards intermittent production depending on environmental factors) leads to even more complex challenges for network operations. Possible solutions include real-time data collection and analysis, use of control units and implementation of demand side management mechanisms.

3.5 How to efficiently achieve energy access for all?

Not achieving a supply of 100% of the population with electricity means not harnessing the full economic potential and at the same time depriving people from benefits of most modern technology. Energy access will push welfare creation. An optimal approach will mix on- and off-grid solutions depending on villages' characteristics (location, resources etc.). Best practice approaches and sound decision criteria for their selection will help to efficiently shape a successful energy access for all and grid connection programme.

3.6 How to make electricity grids fit for renewable energies?

Steep learning curves for photovoltaic and wind energy bring down costs of renewable energies and lead to a growing share of intermittent electricity feed-in (even more so, if supported by policies and regulation as in many countries). The intermittent and hard to control nature of this generation can cause severe problems for network operations. These can be handled through smart grid approaches such as integrated distributed storage systems or demand side management mechanisms.

3.7 How to use information to deliver best in class services?

New technologies such as sophisticated field devices and an advanced metering infrastructure are providing a vast amount of data, which needs to be efficiently collected, pre-processed, stored, and made available to all relevant processes within and maybe even outside the utility company (cross-silo). It needs a structured convergence of information technology and operational technology, which has to be effectively managed to realise the huge potential benefits through utilising this so-called big data, while ensuring high cyber security standards.

3.8 How to improve customer satisfaction?

Customers experience digitalisation in all areas of their life, which leads to growing expectations for new products and services. At the same time, smart grid technologies can be a powerful source for enhancing customer insights, better understanding their needs and designing the right products and services for them. For successfully using this source, customer service processes need to be redesigned or even newly introduced.

3.9 How to encourage customer engagement?

The 'big data' that will be available in the future in combination with connected sensors and control units can be used to design and provide incentives to influence customer behaviour. It can encourage customer engagement in such a way that it provides added value to the customers themselves as well as benefits to the grid. This allows to design of powerful win–win situations. An example is tariff-induced peak-shaving or -shifting.

3.10 How to avoid negative newspaper headlines?

Utilities enjoy positive headlines about innovation projects just as any other company does. Negative headlines on utilities in newspapers, however, are sometimes also picturing utilities not adequately fulfilling their mandate for power supply or having accident events. A well-designed smart grid programme minimises such events (e.g. power outages, accidents etc.) and optimises the organisation's stakeholder management at the same time.

Together with Siemens, PLN took the first step of the Siemens Smart Grid Compass® approach to answer these questions and set up a smart grid implementation programme, which is fully executable and prepares PLN for successfully handling its tremendous challenges.

4 A structured approach for smart grid implementation

The Smart Grid Compass® is a method to evolve an existing grid into a Smart Grid comprising Siemens' global experience in building, operating and maintaining electrical grids. Within the Smart Grid Compass® knowledge, insights and experience of our leading engineers are formalised and aggregated to the benefit of our customers. Previous studies and research by Siemens in the domain of strategic grid asset management provided the impetus for integrating these concepts with a capability maturity model in the Smart Grid domain.

The Smart Grid Compass® Framework establishes a structured 360° view on the development of a utility of today into a utility of the future. The 360° distinguish four quadrants that represent the core business areas of an electric utility. Fig. 1 shows the five business areas of the Siemens Smart Grid Compass® [3, 4].

The four business areas are tied together by the smart organisation needed to implement the changes in the company structure to enable synergies of a smart grid roadmap and foster the change management within the utility. All business areas are typically executing business processes in order to achieve certain objectives such as system reliability, compliance to regulation etc. Those objectives are levered by an orchestrated use of different technologies in the field and require integration in order to profit from synergies between processes and technologies.

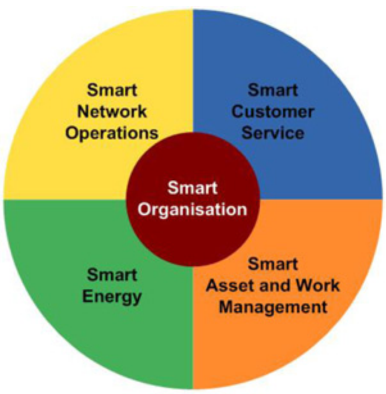

Fig. 1 *Smart grid compass*

The Smart Grid Compass® takes care of this orchestration by consistently connecting the following three dimensions:

Business objectives – These are the major goals of any given business area and are achieved by the individual contribution of the business processes to these objectives. The framework comprises four major objectives in each business area.
Business process capabilities **–** Business objectives can only be achieved by improving the corresponding business process capabilities by enabling technological levers. The framework comprises up to eight major processes in each business area.
Technologies – Technologies generally enable more sophisticated business process capabilities and therefore add business value by contributing to business objectives.

These dimensions are connected by an initiatives catalogue that contains project blueprints originating from Siemens' experiences with projects and concepts in the Smart Grid environment. It is used to provide a connected view regarding process improvements made through the leverage of technology achieving impact on objectives to build a Smart Grid Programme on the experience of Siemens.

Given the broad range of an energy company's activities and the vast range of available technologies, the task of integrating these technologies with the organisation's overall vision, mission, and objectives becomes quite complex. Radically new capabilities inherent in new smart grid technologies that are far in advance of existing infrastructure – around which legacy business models have been constructed – further add to this complexity.

5 The path towards Indonesia's energy system of the future

A utility company can best achieve its business objectives by developing robust business models, creating detailed roadmaps for realising these models, and formulating a concrete implementation plan. In a structured process, business objectives and technological possibilities are aligned to create value.

The value creation process relies on changing the management processes to achieve gains in efficiency by using technological innovations. In order to create sustainable value, such a massive change in business processes and technological capabilities of an organisation must also take into account the changes in business environment, regulatory mechanisms, and energy efficiency goals. Continuous and regular updates of the smart grid programme with the utility's Programme Management Office are needed, to track progress of implementation programmes. Built around an iterative value management approach, the Siemens Integrated Smart Grid Strategies use Siemens' Top+methodology to track target achievement over the course of an entire programme for each initiative.

The Orientation phase of the Siemens Smart Grid Compass® was applied to the Indonesian context to achieve the key target of the consulting project, which was to come up with a Smart Grid Roadmap as requested by PLN's Corporate Planning Directorate. This roadmap enables PLN to integrate smart grid approaches into the implementation of the Indonesian ambitious electricity infrastructure programme.

Implementing the developed Smart Grid Roadmap will support Indonesia on its fast track of their energy infrastructure development along the following priorities:

- avoidance of blackouts and increased capacity in the Java–Bali system,
- efficient end-to-end planning of energy systems,
- establishment of state-of-the art management processes,
- improved reliability and grid access in remote areas (rural areas and islands),
- integration of renewable energies aligned with the structured implementation of technologies under the memorandums of

CIRED, Open Access Proc. J., 2017, Vol. 2017, Iss. 1, pp. 2484–2487

understanding, which were already signed by PLN to ensure maximum effectiveness of the planned investments.

5.1 Next steps

Indonesia plans to ramp up generation from renewable energy sources significantly. As generation characteristics of renewable energies differ from conventional electricity generation and are not easy to control, it is important to plan its integration thoroughly to make intelligent use of diverse approaches from electricity-storage systems over smart tariff designs to microgrid concepts. The ambitious grid development plans require a detailed analysis of required efforts and potential value to determine best-fitting technologies and necessary capability developments. Due to the diverse structure of Indonesia, with its more than 5000 inhabited islands, a detailed regionally differentiated approach is needed to cater for the distinct needs. Based on experiences with Smart Grid Transformation programmes, Siemens proposes a regional segmentation for the overall planning: PLN should continue its smart grid planning in three separate work streams to cater for the regional differences that require a differentiated approach:

(i) Main Island system – Java–Bali and Sumatera: These areas are characterised by a large number of customers. Here, the focus lies on generation expansion, grid reliability and outage prevention.
(ii) Medium-sized Islands such as Sulawesi and Kalimantan: The focus lies on stabilising the infrastructure and system dynamics, increasing penetration of renewable energies for grid stabilisation and giving access to electricity and/or stabilising the grid to prepare for an extension of industrial activity.
(iii) Small-Island systems and isolated networks: Here, the main question is how to provide energy access and a combination of suitable on-grid/off-grid solutions to move away from the dependency of fossil fuel transports.

6 Conclusions

The described collaboration of all involved partners leads to a successful development of a smart grid roadmap for Indonesia. Using the Siemens Smart Grid Compass® method and bringing together technical and business knowledge, broad experiences, local and global expertise, a common understanding of smart grid capabilities and opportunities for Indonesia was created, put in relation with existing objectives and regional challenges for the future development of Indonesia's electricity networks. Following the joint strategy development it is planned to realise the developed smart grid roadmap to further develop and modernise Indonesia's electrical network. The gathered experiences should also be used to transfer lessons learned and proven approaches to ASEAN and other power utilities to support them successfully managing their own energy transition challenges.

7 Acknowledgments

The presented case study was based on a project that was funded by Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH.

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