ENERGY TRANSITION PARTNERSHIP

REPORT

Development of Vietnam Smart Grid Roadmap for period up to year 2030 with a vision to 2050

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Development of Vietnam Smart Grid Roadmap for period up to year 2030, with a vision to 2050

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ACRONYMS

AA	Advanced Analytics
AC	Alternating Current
ADMS	Advanced Distribution Management System
AGC	Automatic Generation Control
AI	Artificial Intelligence
AMI	Advanced Metering Infrastructure
AMR	Automatic Meter Reading
BAN	Building Area Network
BDD	Behaviour Driven Development
BESS	Battery Energy Storage Systems
CA	Certificate Authority
CAGR	Cumulative Annual Growth Rate
CfD	Contract for Difference
CIS	Customer Information System
DER	Distributed Energy Resources
DERMS	Distributed Energy Resource Management System
DGA	Dissolved Gas-in-oil Analysis
DLR	Dynamic Line Ratings
DMS	Distribution Management System
DoS	Denial of Service
DR	Demand Response
DSM	Demand Side Management
DTCR	Dynamic Thermal Circuit Rating
DTG	Direct Trading Generator
EE	Energy Efficiency
EMS	Energy Management Systems
ERAV	Electricity Regulatory Authority of Viet Nam
ETP	Southeast Asia Energy Transition Partnership
EV	Electric Vehicle
EVN	Electricity of Viet Nam
EVNHCMC	Ho Chi Minh City Power Corporation
EVNNPT	National Power Transmission Corporation
EWEC	East West Energy and Climate Link JSC
FACTS	Flexible AC transmission Systems
FAN	Field Area Network
FIT	Feed-in Tariff
FLISR	Fault Location, Isolation and Service Restoration
FLS	Fault Locator System
FMSR	Fault Management and System Restoration
GENCO	Generation Corporation
GIS	Geographic Information System
HAN	Home Area Network

HCMC	Ho Chi Minh City
HVDC	High Voltage Direct Current
IAN	Industry Area Network
ICT	Information Communication Technology
IDS	Intrusion Detection System
IEC	International Electrotechnical Commission
IES	Intelligent Energy Systems
IP	Internet Protocol
IPS	Intrusion Prevention System
IPSec	Internet Protocol Security
IT	Information Technology
LAN	Local Area Network
LLS	Lightning Location System
LV	Low Voltage
MDAS	Metering Data Acquisition System
MMS	Market Management Systems
MOIT	Ministry of Industry and Trade
MW	Mega Watt
NAN	Neighbourhood Area Network
NLDC	National Load Dispatch Center
NPT	National Power Transmission Corporation
OCC	Operation Control Centres
OMS	Outage Management Systems
P2P	Peer to Peer
PC	Power Corporation
PDP	Power Development Plan
PKI	Public Key Infrastructure
PMU	Phasor Measurement Unit
RE	Renewable Energy
RLDC	Regional Load Dispatch Center
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SAS	Substation Automation System
SCADA	Supervisory Control and Data Acquisition
SCED	Security Constrained Economic Dispatch
SG	Smart Grid
SGI	Smart Grid Indices
SPPA	Solar Power Purchase Agreement
SVC	Static Var Compensators
TLS	Transport Layer Security
TOR	Terms of Reference
TSO	Transmission System Operator
UNOPS	United Nations Office for Project Services
V2G	Vehicle to Grid

VPN	Virtual Private Network
VPP	Virtual Power Plant
VRE	Variable Renewable Energy
VREM	Viet Nam Retail Electricity Market
VWEM	Viet Nam Wholesale Electricity Market
WAMS	Wide Area Monitoring Systems
WAN	Wide Area Network

EXECUTIVE SUMMARY

Since 2012, Viet Nam has to date been implementing a Smart Grid Development Roadmap defined by Prime Minister Decision No. 1670/QD-TTg (8 November 2012). Since that time, Viet Nam's policies and energy sector has evolved with significant growth in renewable energy and expectations for scaling up of energy storage technologies, wider use of electric vehicles and a shift towards more distributed energy resources. The Smart Grid Development Roadmap therefore needs to be revisited for several reasons: firstly, to be aligned with Viet Nam's expected future generation mix and technologies, secondly, to ensure that advances in Smart Grids are reflected and finally, to create the impetus for continuing the process of grid modernization.

The objective of this report is to offer insights and recommendations to the development of a new roadmap that can effectively address the current and anticipated challenges facing the Vietnamese power grid for the period up to 2030, with a vision for 2050. It is therefore contributing to the development of a Smart Grid in Viet Nam that is both effective and sustainable, enabling Viet Nam to meet its energy needs while reducing greenhouse gas emissions and promoting economic growth.

This report is part of a wider Technical Assistance initiative of the Energy Transition Partnership (ETP) in collaboration with the Electricity Regulatory Authority of Vietnam (ERAV) to provide recommendations on how the 2012 Smart Grid Development Roadmap can be updated to accommodate recent changes to Viet Nam's policy framework and to support a significant increase in renewable energy.

Smart Grid Roadmap Requirements

The requirements for Viet Nam's Updated Smart Grid Roadmap arise from consideration of two assessments that were the subjects of the reports: "Study Report on the Status of Smart Grid development in Viet Nam" (28 November 2023) and "Study Report on Smart Grid Technology and International Experience" (13 December 2023).

Firstly, the report on the Status of Smart Grid development in Viet Nam undertook an assessment of the progress that Viet Nam had made in the implementation of the Current Smart Grid Roadmap, and concluded that while most of the targets and development goals had been achieved, there remained several areas that would be crucial to implement to lay the platform for future Smart Grid deployment:

- Further modernization in monitoring and control of real-time power system operations to enhance power system visibility and flexibility to manage higher levels of renewable energy,
- Continue to progress remote meter monitoring, implementation of Advanced Metering Infrastructure and eventually smart metering infrastructure,
- Advance infrastructure and monitoring capabilities to better accommodate distributed energy resources (DER) including behind-the-meter solar rooftop PV, behind-the-meter energy storage, intelligent end-use appliances and electric vehicle charging infrastructure,
- Continue to promote Demand-Side Management, Demand Response, Energy Efficiency to maximize participation and engagement of end-users – thereby capturing opportunities for flexibility in the demand-side.

Secondly, the "Study Report on Smart Grid Technology and International Experience" carried out a technological review of smart grid technologies and identification of implications for regulatory frameworks and technical standards that are necessary to support the implementation and rollout of Smart Grid technologies. Specific issues of relevance to Viet Nam that were identified included:

- Accommodating future generation technologies including smart inverters, utility-scale battery energy storage systems, and Virtual Power Plants (VPPs),
- Supporting advances in transmission technologies and operational applications including Flexible AC transmission (FACTS) devices, HVDC technologies, real-time monitoring and management of variable renewable energy resources, Dynamic Line Ratings (DLR), WAMS/PMUs, and special protection / control schemes to maximize the utilization of the network,
- Supporting advances in distribution network technologies and operations: Advanced Distribution Management Systems (ADMS), Fault Location, Isolation and Service Restoration (FLISR) technology, real-time GIS maps and displays, substation automation systems, and distributed energy resource management systems (DERMS),
- Creating an environment that encourages greater end-user engagement and activeness, including Advanced Metering Infrastructure (AMI), Meter Data Management Systems (MDMS), Smart Meters, Home Automation Systems, intelligent appliances, intelligent Building Energy Management Systems, and Internet of Things (IOT) to increase demand flexibility,
- Improve the scope, bandwidth, reliability, and nature of communication networks – including Wide Area Networks (WANs), Local Area Networks (LANs), and smaller scope networks such as Neighborhood Area Networks (NANs), Home/Building/Industry Area Networks (HANs, BANs, and IANs) to support 2-way communications and transfers of information on all connected devices / appliances,
- Enhance data management systems and analytics through the deployment of cloud-based servers and data warehouses, edge computing, GIS mapping and analysis software packages, artificial intelligence,
- Take measures to ensure Cyber Security risks and threats are preempted and mitigated against.

Collectively, these requirements have formed the basis for the Updated Smart Grid Roadmap.

Recommended Updated Smart Grid Roadmap

Our proposed Updated Smart Grid Roadmap has been structured to be consistent with the original Smart Grid Development Roadmap of Prime Minister Decision No. 1670/QD-TTg (8 November 2012), with a focus on actions and targets to the year 2030, and actions and targets to be achieved by 2050.

Objectives: The Updated Smart Grid objective is to continue the development of an Smart Grid with modern technologies that aim to enhance power quality and supply reliability, contribute toward the efficient management of power demand, encourage efficiency in the use of energy resources, enhance labour productivity, reduce demand of investment in power grid and source development, strengthen reasonable exploitation of energy resources, ensure national energy security, and support energy sector transition towards net zero greenhouse gas emissions by 2050 and contribute towards environmental protection and sustainable socio-economic development.

Legislation and Technical Standards: Legislation and technical standards need to support the entry and/or integration of new technologies. The Updated Smart Grid Roadmap assigns the responsibilities for the regulations to relevant ministerial bodies which are to be implemented concurrently with the rollout and integration of Smart Grid technologies in Viet Nam.

Real-Time Monitoring and Control: Establishing a reliable real-time monitoring platform for Viet Nam's power system is the core requirement for deployment of more advanced tools and applications that can support the integration of higher levels of renewable energy, encourage efficiency and generally support the energy sector transition. Traditionally real-time monitoring has been focused on the high voltage, / generation and transmission part of the industry, however, the increasing trend towards distributed energy resources (DER) including behind-the-meter rooftop PV and behind-the-meter BESS, is necessitating the need for the market and system operator to have greater real-time visibility of the power system and have coverage of a subset of distribution network assets.

Substation automation: The overriding objective of substation automation and remote-control devices is to reduce to 3-5 persons on the duty per 110 kV substation and transition switching operations for medium-voltage equipment to be done remotely. It is noted that presently there must be at least 1 person attending at any fully automated substation to satisfy the fire safety / prevention requirements.

Modernization of Metering Infrastructure: Modernization of metering infrastructure is an important step towards automation and generally forms an important precondition for roll out of Smart Grid technologies and platforms such as Demand Response, VPPs, smart end-use appliances, improved consumer engagement / participation in electricity markets, Distributed Energy Resources, and participation of prosumers in general. While Viet Nam has made some progress in this area under the previous Smart Grid Roadmaps, as such the Updated Smart Grid Roadmap has put in place a step-by-step strategy to improve the metering arrangements over time, with responsibilities assigned to NPT and the PCs.

Promotion of programs and special initiatives: To promote and create incentives in the industry to advance smart grid technologies in Viet Nam, several important programs have been identified to be important. Those recommended to be implemented by 2030 include: (1) Commercial DR programs, (2) Distributed Energy Resource integration, and (3) Systems to support the integration of Electric Vehicles charging stations in the grid.

Data Management and Analytics: Deploy Geographic Information System (GIS) tools and real-time monitoring facilities or transmission and distribution networks, roll out Advanced Analytics (AA) and Artificial Intelligence (AI) driven applications to enhance energy consumption monitoring, demand forecasting, equipment condition assessment and system fault forecasting, and transition towards greater use of cloud-based computing and containerisation solutions for analytics and data management.

Communications Infrastructure: By 2030, ensure that 100% of rural district power companies have fibre-optic connections in place so that they will be connected to a dedicated EVN system.

Cyber Security: Cyber security within the context of smart grids is concerned with taking measures across all organisations within the electricity industry to ensure: (1) confidential data is protected, (2) ensuring the integrity of data and information, (3) putting in place measures to ensure authentication and only authorised access is provided to data, (4) auditing and monitoring to ensure continuous improvement, (5) having measures in place for handling breaches in cyber security – incident response, (6) ensuring staff are aware of security risks at all times, and (7) complying with other standards and regulations.

Power System Performance Measures: As with the original Smart Grid Roadmap, a number of performance measures have been introduced into the Updated Smart Grid Roadmap, requiring

Vietnam to trend towards international best practices for: (1) system reliability, (2) electrical losses, and (3) threshold on curtailment levels of variable renewable energy resources.

Research and development: Continue to promote initiatives by the industry to undertake research and development in Smart Grid technologies with a focus on piloting and testing new technologies ahead of their wide scale deployment and scaling up.

Organizational implementation: MOIT with ERAV support will establish a Smart Grid Steering Committee that will have representation of the following ministries: Finance, Planning and Investment, Science and Technology, Construction, the Viet Nam Electricity Group, and other relevant agencies / units. The purpose of the Steering Committee is to direct, monitor and oversee implementation of the Updated Smart Grid Roadmap. While Viet Nam has made some progress in this area under the previous Smart Grid Roadmaps, as such the Updated Smart Grid Roadmap has put in place a step-by-step strategy to improve the metering arrangements over time, with responsibilities assigned to NPT and the PCs.

Benefits of an Updated Smart Grid Roadmap

The Updated Smart Grid Roadmap will benefit key stakeholders, including ERAV, Electricity of Viet Nam (EVN), power generation companies, transmission and distribution entities, and electricity consumers as a technology roadmap to support Viet Nam's energy transition to the year 2050. The Updated Smart Grid Roadmap plays a role in enhancing the quality and reliability of electricity supply, and the promotion of efficient utilization of energy in relation to accommodating a higher share of renewable energy in Viet Nam's power system as part of the transition towards Net Zero Emissions by 2050. The successful deployment of Smart Grid technologies will play a role in overcoming the challenges that commonly arise in power systems that have a high share of renewables including reduction in VRE curtailment, increased utilisation of transmission assets and avoidance of excessive transmission congestion, improved visibility of the power system to improve reliability and stability, overcoming the reduction in system inertia, supporting grid flexibility and enhancing end-user responsiveness and participation.

The Updated Smart Grid Roadmap is expected to guide policy development and form the basis of legislation that is required and the roll out of solutions to modernize the grid. High priority actions for the period to 2030 include early introduction of technical standards and codes, completing investments in substation automation and SCADA/EMS infrastructure to enhance monitoring and automatic control of the power system. Secondary priorities relate to the roll out of smart meters in conjunction with policies that promote prosumers and greater participation of electricity consumers in the power system.

As Smart Grids evolve there is a need for coordination between the electricity sector, building and construction sector and transport sector. To enhance coordination between these areas the Smart Grid roadmap additionally proposes to have a Steering Committee to coordinate these different areas and oversee and monitor its implementation. The Smart Grid additionally identifies the necessary regulations to govern the technologies and create incentives for their deployment to be successful. It also identifies areas of research that can be leveraged and identifies the need for capacity building to support its implementation in Viet Nam.

As such, the outcome of this project will support Viet Nam in its transition towards a more dependable, environmentally friendly, and efficient energy system, contributing to one of ETP's strategic objectives focusing on the expansion of smart grids.

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1 Introduction

1.1 Project Background

Intelligent Energy Systems Pty Ltd (IES) and East West Energy and Climate Link JSC (EWEC) have been selected by UNOPS to carry out the project titled *“Development of Viet Nam Smart Grid Roadmap for period up to year 2030, with a vision to 2050”*. This project is implemented under the UNOPS Southeast Asia Energy Transition Partnership (ETP) in cooperation with the Electricity Regulatory Authority of Viet Nam (ERAV).

Viet Nam has been implementing the current Smart Grid Development Roadmap since 2012, following the Prime Minister’s Decision No. 1670/QD-TTg dated 8 November 2012. However, the existing roadmap has not been updated to align with Viet Nam's evolving policies and the significant growth in renewable energy sources. In this context, the project aims to offer insights and recommendations to the development of a new roadmap that can effectively address the current and anticipated challenges facing the Vietnamese power grid. This new roadmap is hence required to ensure the reliability and sustainability of the energy system, aligning with the objectives of Power Development Plan VIII and Viet Nam's commitment to achieving net-zero emissions, as well as meeting the targets formulated under the Just Energy Transition Partnership (JETP). It will outline a strategic plan for the efficient integration of renewable energy sources into the grid, enabling it to operate in a more robust, secure, and sustainable manner.

This project aims to deliver benefits to key stakeholders, including ERAV, Electricity of Viet Nam (EVN), power generation companies, transmission and distribution entities, and electricity consumers. Its primary output will be formulation of a Smart Grid Development Roadmap, covering the period up to 2030, with an extended vision to 2050. The goals of this roadmap are to enhance the quality and reliability of electricity supply and promote the efficient utilization of energy. Additionally, the project will offer recommendations for addressing challenges in policy, legislation, economics, and technology, accompanied by proposed solutions for implementation. As such, the outcome of this project will support Viet Nam in its transition towards a more dependable, environmentally friendly, and efficient energy system, contributing to one of ETP's strategic objectives focusing on the expansion of smart grids.

1.2 Project Objective and Outputs

The objective of the project is to formulate inputs and recommendations to support the development of a new Smart Grid Development Roadmap to guide and accelerate the development of smart grid technologies in Viet Nam with actions to year 2030, and a vision to year 2050. The new roadmap is intended to supersede the Smart Grid Development Roadmap of Viet Nam that was promulgated in Decision No. 1670/QD-TTg.

The main outputs of this project include:

- Research and Study reports
- Consultative Workshop
- Proposed Smart Grid Development Roadmap

1.3 Objectives and Scope of this Report

The objective of this report is to prepare a detailed roadmap for smart grid development in Viet Nam for the period up to 2030, with a vision for 2050. It is to be a comprehensive and strategic plan for the development of a Smart Grid in Viet Nam that is both effective and sustainable, enabling Viet Nam to meet its energy needs while reducing greenhouse gas emissions and promoting economic growth.

Issues to be addressed include:

- Adjustments to phase 3 of the smart grid roadmap of Decision No. 1670/QD-TTg-2012, and must consider policy, legal, economic, technical feasibility, and solutions for implementation.
- An analysis of the power system.
- Analysis of additional power generation plants to be connected within the planning period.
- Quantification of peak demand.
- Assessment of the readiness of the grid.
- Identification of suitable grid technology options and provision of rationale for the selection – including consideration of costs, intermittency, variability, system congestion, lack of inertia, flexibility, reliability, power quality, communication/ ICT, cybersecurity, sustainability of system (e.g., upgrades of obsolete system or software), and so on.
- Scenarios for the deployment of smart grid.
- Assessment of potential greenhouse gas emission reduction resulted from the scenarios.
- Using suitable methodologies to rationalise for the scenarios and major potential items (e.g., cost and benefit analysis, quantitative analysis).
- Identification of the implementation phases and suggesting areas of focus / projects for each phase.
- Recommendations for the development of smart grid in diverse aspects, including regulatory framework and policies, financing schemes, real time pricing schemes, capacity building for energy utilities and regulators on smart-grid deployment and operation, and so on.

1.4 Note on Terminology

We use the following terminology in this report:

- **Current Smart Grid Roadmap**: refers to the present Smart Grid Roadmap in Viet Nam, as defined by the following key legislation:
  - Prime Minister Decision No. 1670/QD-TTg (dated 8 November 2012)
  - MOIT Decision No. 4602/QD-BCT (dated 25 November 2016) approving the comprehensive Smart Grid Development Plan.
- **Updated Smart Grid Roadmap**: refers to the proposed new Smart Grid Development Roadmap to 2030, with vision to 2050.

1.5 Approach

Firstly, we identify the requirements for the Updated Smart Grid Roadmap by drawing upon the results and content of the following two previous deliverables:

- Study report on the status of smart grid development in Viet Nam, and
- Study on international experience.

In essence we arrive at a list of requirements for the Updated Smart Grid Roadmap to address in the following way:

- Requirements from implementation of Smart Grid to date in Viet Nam,

- Requirements based on a review of technologies,
- Requirements based on international case studies and lessons, and
- Requirements for cyber security within the context of Smart Grid.

Based on the requirements and on the original Smart Grid Roadmap of 2012, a proposed Updated Smart Grid Roadmap is presented. It has been divided into actions that are relevant for the near-term, which is to the year 2030, and actions in the longer-term to the year 2050. It has been matched to Viet Nam's roadmap structure and forms the basis for the updated roadmap.

1.6 Report Structure

This report is structured accordingly to cover our findings, comprising the following main sections:

- Section 2 determines the implications for the Updated Smart Grid Roadmap based on implementation progress in Viet Nam against existing policies and legislation,
- Section 3 provides a quick recap of important smart grid technologies and identifies those that need to be considered within the Updated Smart Grid Roadmap,
- Section 4 summarises the main lessons from the review of international experience and identifies further implications for the Updated Smart Grid Roadmap,
- Section 5 discusses the issue of cyber security within the context of Smart Grids and identifies areas that need to be considered in the Updated Smart Grid Roadmap.
- Section 6 sets out the Updated Smart Grid Roadmap that has been proposed based on the preceding analysis,
- Section 7 provides guidance on the implementation of the Roadmap, and
- Section 8 provides the conclusions.

2 Roadmap Requirements based on Implementation Status

2.1 Purpose

The purpose of this section is to recap progress made on Viet Nam's smart grid roadmap implementation, identifying areas that remain to be implemented and determining the implications and requirements to be integrated into the Updated Smart Grid Roadmap. This section presents the Consultant's findings in review of the Vietnamese smart grid implementation status.

2.2 Current Smart Grid Roadmap Policy Framework

There are two key policy documents guiding Smart Grid development in Viet Nam:

- Prime Minister Decision No. 1670/QD-TTg (dated 8 November 2012) which sets out the first Smart Grid Development Roadmap, and
- MOIT Decision No. 4602/QD-BCT (dated 25 November 2016) approving the comprehensive Smart Grid Development Plan.

2.2.1 Smart Grid Development Roadmap Policy (2012)

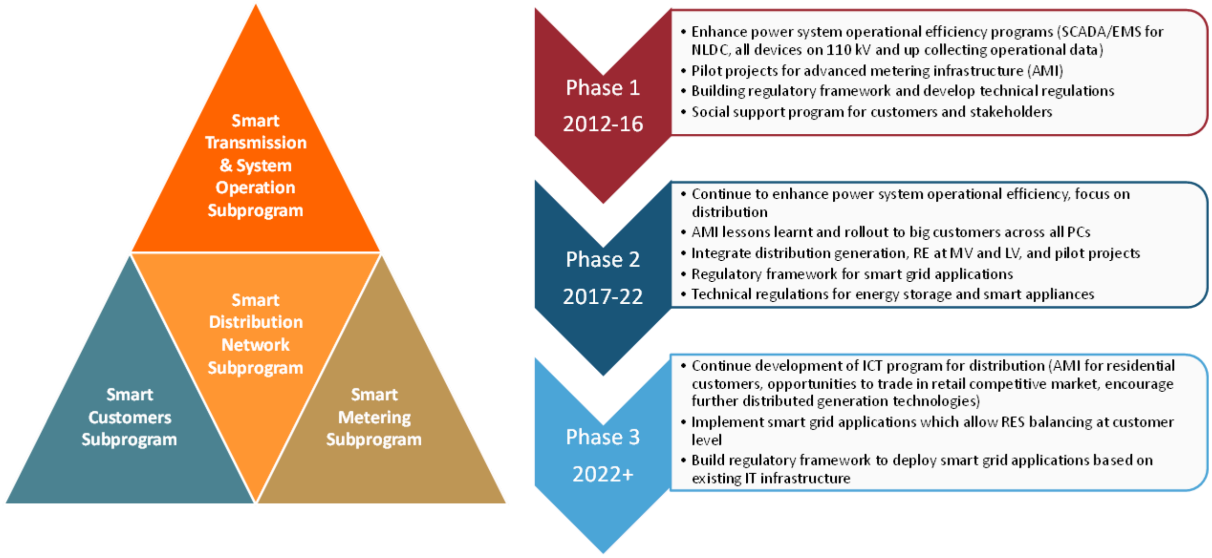
Figure 1 shows the PM Decision No. 1670/QD-TTg showing how the Smart Grid Roadmap was broken down into four subprograms and three phases, with the subprograms considered being:

- Smart Transmission and System Operation,
- Smart Distribution Networks,
- Smart Customers, and
- Smart Metering.

As illustrated it considered three basic phases with the first two being 5-year periods:

- **Phase 1** (2012-2016): focusing on development of basic regulations and improving power system efficiency. Main objectives for this period included establishment of a comprehensive data collection, monitoring, and control system (SCADA) and remote metering systems for all power plants with a capacity greater than 30 MW, substations with voltages of 110 kV and above; deployment of all functions of the Energy Management System (EMS) at the National Load Dispatch Center and regional load dispatch centers; and initial implementation of automated operations and remote control of substations in the power system.
- **Phase 2** (2017-2022): focusing on automation of transmission grid and AMI for large customers. Main activities designated for this stage were to continue the deployment and enhancement of SCADA systems for the Power Corporations, equip automation systems for 110kV substations, and install remote metering systems for large electricity consumers.
- **Phase 3** (from 2023 onwards): focusing on automation of distribution grid and AMI for all customers. One of the main goals of this phase would be to implement Smart Grid applications that allow monitoring the real-time supply-demand balance at the user level.

Figure 1. Viet Nam's Smart Grid Development Roadmap (PM Decision No. 1670/QD-TTg)



2.2.2 Smart Grid Development Plan (2016)

The Smart Grid Development Plan approved under Decision 4602/QD-BCT in 2016 sets out a more detailed set of targets within the roadmap's objectives with important targets being:

- By 2020, completion of SCADA/EMS and SCADA/DMS systems for the NLDC, Regional Load Dispatch Centers (RLDCs), the Power Corporations (PCs), and selected power distribution companies; all power plants with capacity over 30 MW, 500 kV and 220 kV substations are connected to the SCADA system and provide sufficient SCADA signals.
- By 2020, transition of 60% of 220 kV substations and 100% of 110 kV substations under the management of the NPT and PCs to unstaffed (fully automated) or lesser-staffed models of operation.
- By 2017, completion of remote metering and data collection systems at all wholesale metering points of the NPT and PCs, and by 2020 – installation of electronic meters and remote data collection systems for approximately 50% of electricity consumers.

2.3 Progress in Smart Grid Roadmap Implementation

2.3.1 Achievements in implementation

The main areas of Viet Nam's Current Smart Grid Roadmap that have been successfully implemented include:

- Deployment of technology infrastructure to support power system automation and RE integration. This included the completion of SCADA/EMS systems for power plants and high voltage substations (110kV and above), automated operations of high voltage substations.
- Rollouts of electronic meters, and remote meter reading and data collection.

These have contributed toward improvements in reliability and quality of electricity supply, reflected in the form of a reduction in power losses and improvements in the SAIDI and SAIFI measures of reliability.

2.3.2 Implementation impediments

Our review also identified impediments to the Smart Grid Roadmap implementation and targets that were not yet satisfied, as follows:

- While there has been the roll out of the SCADA / EMS and/or SCADA / DMS which has addressed basic applications and functionality, such as Automatic Generation Control (AGC) and State Estimation, other more advanced functions of EMS and DMS have not been fully utilized due to inadequacies in SCADA signals / measurements that are received at various locations on the network and across all necessary voltage levels.
- Advance Metering Infrastructure (AMI) including Smart Meters have not been rolled out to customers with potential increases to the electricity supply costs being indicated as a key impediment.
- To date, there has been no commercial Demand Response (DR) or Demand Side Management (DSM) programs implemented because of there being a lack of mechanisms to provide the required financial support to create incentives on participants to implement such programs.
- There is no policy framework or technical regulations in place at this stage to support the roll out of energy storage systems.
- Other technology innovations including smart grid applications, zero energy buildings, and smart appliances have not been initiated.

2.3.3 Assessment of Smart Grid Roadmap Implementation

In our review of the smart grid implementation we provide an analysis of the Smart Grid Roadmap targets against implementation progress, which is summarised in Table 1 and Table 2 and presented as a comparison of the actions taken and outcomes against objectives and targets of Decision 1670/QD-TTg and Decision 4602/QD-BCT. This is important because unresolved issues need to be incorporated in the Updated Smart Grid Roadmap, as explained in the tables. The tables identify features in Current Smart Grid Roadmap that we recommend carrying forward into the Updated Smart Grid Roadmap or unsatisfied targets / objectives that are yet to be achieved, but which continue to be important.

Table 1. Smart Grid Roadmap Objectives from Decision 1670/QD-TTg (2012) and Results Achieved as of 2022

No	Smart Grid Objective (2012)	Result Achieved (by End of 2022)	Implication for Updated Smart Grid Roadmap to 2030	Implications for Updated Smart Grid Roadmap to 2050
1	Establish legal framework for Smart Grid Development by reviewing, amending, and supplementing existing legal documents in the electricity sector; promulgating new documents related to development of renewable energy sources; and developing relevant technical standards and regulations.	Policy documents have been issued to provide legal frameworks for: • Frequency regulation and ancillary services operation in conjunction with the integration of a significant amount of RE sources. • Establishment of Remote-Control Centres (RCC) / Remote Operation Centres (ROC) and automated substations to facilitate remote control and switching of electric equipment in the power system. • Application of remote metering and metering data collection. • Criteria or assessment of the electricity industry development. • Technical requirements and operational management of the SCADA/EMS/DMS system. • Load research and Pilot Demand Response Program. Legislation not yet developed: • Incentive mechanism for smart grid applications in new and renewable energy • Incentive mechanism for smart grid applications in zero energy buildings. • Incentive mechanisms for smart grid applications in energy trade between customers and power	Documentation that is not yet promulgated or developed still needs to be developed and included in the Updated Smart Grid Roadmap. This should reflect expected generation technologies up to the year 2035 because lead-time in policy ahead of technology roll out should be considered.	Regulations and standards for new technologies that will enter beyond 2035.

No	Smart Grid Objective (2012)	Result Achieved (by End of 2022)	Implication for Updated Smart Grid Roadmap to 2030	Implications for Updated Smart Grid Roadmap to 2050
		companies. • Incentive mechanisms for residential customers participation in DSM. • Regulations for integration of energy storage systems. • Regulations for smart appliances capable of adjusting the demand based on supply conditions or electricity tariff.		
2	By 2013, establish a comprehensive data collection, monitoring, and control system (SCADA) and remote metering system for all power plants with a capacity greater than 30 MW, as well as substations with voltages of 110 kV and above within the national power system.	• Power plants with a capacity more than 30 MW: 100% power plants have been equipped with SCADA system, compared to the rate of 92% in 2013. For these power plants, 93.64% of the SCADA connections currently provide stable signals, a significant improvement in comparison to that rate of 46% in 2013. • 500kV substations: 100% of 500kV substations have been connected to the SCADA system. The proportion of 500kV substations having sufficient SCADA signals has increased to 92.68%, compared to 42% in 2013. • 220kV substations: All 220kV substations have their SCADA systems connected, with 87.9% of them providing stable signals. • 110kV substations: SCADA connections have been set up at 97% substations of this voltage level, with 86.58% transmitting good signals.	Updated targets for real-time data collection up to the year 2030.	Not any
3	By 2016, all the functionalities of the Energy Management System (EMS) of the SCADA/EMS system are fully utilized at the	Basic applications of the EMS system, such as automatic generation control (AGC) and state estimator have been	Improved functionality of the SCADA/EMS is	Tighter integration of SCADA/EMS and

No	Smart Grid Objective (2012)	Result Achieved (by End of 2022)	Implication for Updated Smart Grid Roadmap to 2030	Implications for Updated Smart Grid Roadmap to 2050
	National Load Dispatch Center and Regional Load Dispatch Centers.	deployed in accordance with the operational requirements.	required – including advanced functions.	SCADA/DMS is recommended.
4	By 2022: SCADA/DMS system for Power Corporations; remote metering system installed for all major electricity customers.	• 100% Power Corporations and Provincial Power Companies have been equipped with SCADA/DMS, miniSCADA systems to monitor and control the distribution power grids. • 100% customers with monthly electricity consumption greater than 1 million kWh have remote metering set up.	No targets required for short-term.	Advanced DMS will increasingly be needed to support distributed generation – propose to make this a long-term requirement by 2050 – to better accommodate distributed energy.
5	Improve the reliability of electricity supply: reduce the System Average Interruption Frequency Index (SAIFI) by 10% and reduce the System Average Interruption Duration Index (SAIDI) by 20% after every 5-years period.	Over the last 10 years, SAIFI has decreased 13 times (from 39.24 in 2012 to 2.95 in 2022), and SAIDI has decreased 28 times (from 8,077 minutes in 2012 to 283 minutes in 2022).	A general directive to monitor SAIDI and SAIFI to ensure continuous improvement and no degradation of performance.	
6	Equip automatic and control devices to enhance labour productivity in the power sector: the 110kV substations equipped with automation and remote-control devices would reduce to 3-5 persons on the duty per substation; switching operations for medium-voltage networks would be implemented remotely.	• For 110kV substations: the Power Corporations have successfully put 100% of the RCCs into operation and achieved a 100% rate of 110kV substations operating in compliance with the fully automated criteria. • For 220kV substations: EVNNPT has put 115 out of 146 of 220kV substations or 78.8% into operation in accordance with the unstaffed automated criteria. • However, there are currently no detailed regulations regarding fire prevention and firefighting for fully automated substations, therefore entities still must arrange 01 employees to be physically present at each	Continue to ensure newly added substations are automated – and work to automate all 220 kV substations should be directed with a target of 100% by 2030.	Continue to ensure newly added substations are automated.

No	Smart Grid Objective (2012)	Result Achieved (by End of 2022)	Implication for Updated Smart Grid Roadmap to 2030	Implications for Updated Smart Grid Roadmap to 2050
		substation for fire duty in accordance with current regulations.		
7	Enhance the ability of electricity demand forecast and electricity supply planning, limit load shedding due to supply shortages through mechanisms such as peak load shifting during peak hours or emergency situations: Reduce peak load by 1 - 2% through the application of advanced metering infrastructure (AMI).	• Advanced metering infrastructure for large customers was piloted for HCMC in 2017 but has not been widely implemented afterwards; only Automatic meter reading (AMR) infrastructure has been deployed. • Commercial Demand Response has not been implemented; however, non-commercial Demand Response mechanisms were initiated; a reduction of 513.9 MW in peak demand was achieved in 2019, which was around 1.5% system Pmax.	Roll out of AMI and AMR technology at PCs in tranches – industrial and commercial sectors. Encourage roll out of smart meters with control interface for devices.	Roll out of AMI and AMR technology at PCs in tranches – residential and other sectors. Encourage roll out of smart meters with control interface for devices.
8	Implement technical solutions and management measures with the aim of reducing electrical energy losses (technical and commercial losses) in the transmission and distribution systems from 9.23% in 2011 to 8% by 2015	This objective has been achieved: system power loss factor was 7.94% in 2015 and decreased further to 6.42% in 2022.	A general directive to continue monitoring losses and to ensure continuous improvement and no degradation of performance.	
9	Apply Smart Grid technology to connect and operate reliably new and renewable energy sources, facilitating the efficient utilization of these energy sources contributing to the encouragement of the development and increase of the new and renewable energy source share in the electricity generation mix, and contribute	• 100% RE plants are connected to SCADA and can be monitored and controlled via AGC from the dispatch center. • Rooftop solar systems less than 1 MW do not feature monitoring systems connected to the dispatch center.	Increase dynamic monitoring of solar rooftop systems via the introduction of DER performance and monitoring standard, DER monitoring system.	None

No	Smart Grid Objective (2012)	Result Achieved (by End of 2022)	Implication for Updated Smart Grid Roadmap to 2030	Implications for Updated Smart Grid Roadmap to 2050
	to the environmental protection and ensuring national energy security.			
10	Promote research and domestic production of intelligent electronic products for the technological needs of smart grids; to allow customers to proactively access and manage detailed information about their electricity usage and costs.	• Some entities have proactively carried out research on product development, however, due to the lack of incentive mechanisms and supporting industries, no commercial products have been widely introduced. • Distribution entities have implemented web and mobile applications, allowing customers to monitor and manage specific information about their electricity usage and electricity purchase costs.	Promotion of research and development of new technologies should always be encouraged – particularly running pilots of new technologies to test whether rolling out on a large scale makes sense	

Legend:

(green)	Objective has been achieved in the Updated Smart Grid Roadmap and not required for Updated Smart Grid Roadmap
(yellow)	Continuation of Current Smart Grid Roadmap objective in Updated Smart Grid Roadmap
(orange)	Objective was not achieved in the Current Smart Grid Roadmap but should be adopted in the Updated Smart Grid Roadmap

Table 2. Progress of Smart Grid Development Targets from Decision 4602/QD-BCT (2016)

Area	Target	Target Year	Progress as of end of 2022	Comment	Implication for Updated Smart Grid Roadmap to 2030	Implications for Updated Smart Grid Roadmap to 2050
SCADA & telecommunication infrastructure	National and all regional load dispatching centres, all Power corporations, selected provincial and municipal city power companies are equipped with SCADA/EMS, SCADA/DMS systems.	2020	Completed by end of 2022		Assume this is in place and can be built on.	N/A
SCADA & telecommunication infrastructure	Power plants, substations and control centres are equipped with RTU/Gateway and telecommunication systems	2020	Completed by 2020	RTU/Gateway and telecommunication equipment were installed for power plants, substations, and operation control centres (OCCs)	Assume this is in place and can be built on.	N/A
SCADA & telecommunication infrastructure	100% of power plants capacity above 30 MW, 100% of 500kV and 220kV substations have sufficient SCADA signal transmitted	2020	Completed by 2020		Assume this is in place and can be built on.	N/A
SCADA & telecommunication infrastructure	100% of 110kV substations and power plants capacity between 10 - 30 MW have SCADA signal, 90% of them have sufficient signal transmitted	2020	Almost completed by 2020	Some substations that belong to customers are not connected	Need to encourage remaining customers to connect to reach 100% of 110 kV substations.	None (assume fully completed by 2030)

Area	Target	Target Year	Progress as of end of 2022	Comment	Implication for Updated Smart Grid Roadmap to 2030	Implications for Updated Smart Grid Roadmap to 2050
SCADA & telecommunication infrastructure	Use DMS and EMS systems applications at all dispatching levels	2020	Not fully completed (as of 2020)	Hindered by insufficient SCADA signals	Needs to be investigated and addressed in Updated Smart Grid Roadmap	None (assume fully completed by 2030)
SCADA & telecommunication infrastructure	100% of power plants capacity above 30 MW and 500kV, 220kV substations are connected to a dedicated EVN system via two independent fibre lines	2020	Completed by 2020	100% of power plants with capacity of 30 MW or above, 100% of 110/220/500kV have D2 connections	Assume this is in place and can be built on.	None
SCADA & telecommunication infrastructure	100% of 110kV substations are connected to control centres or dispatching centres via a fibre line	2020	Completed by 2020	100% of 110kV substations and regional power companies have fibre-optic connections installed, except island district power units where microwave channels are used.	Assume this is in place and can be built on.	None
SCADA & telecommunication infrastructure	More than 90% of district power companies are connected to a dedicated EVN system via a fibre line	2020	Completed by 2020	100% urban district power companies and 98% rural district power companies have fibre-optic connections installed (apart from remote island power companies).	Remaining 2% of rural district power companies should eventually be fibre-optically connected	None (assume fully completed by 2030)
Remote control centres for NPT and power corporations	60% of 220kV substations, 100% of 110kV substations controlled by NPT and	2020	220kV: Completed by 2020 110kV: Completed by 2022		Increase 60% to 100% over time	Increase 60% to 100% over time

Area	Target	Target Year	Progress as of end of 2022	Comment	Implication for Updated Smart Grid Roadmap to 2030	Implications for Updated Smart Grid Roadmap to 2050
	power corporations are unstaffed (fully automated)					
Electronic metering and remote metering	Complete installations of the remote electricity metering and data collection systems at all metering points to serve the management, production, and business activities of the NPT and PCs (including metering between different entities and main meters at 0.4 kV distribution substations).	2017	Completed by 2022		Assume this is in place and can be built on.	None
Electronic metering and remote metering	Installation of electronic metering and telemetry function (remote metering) for 50% of customers	2020	Completed by 2022		Target to increase the number to 85% by 2030 and 95% by 2035	Target to increase the number to 100%

Legend:

	Objective has been achieved in the Updated Smart Grid Roadmap and not required for Updated Smart Grid Roadmap
	Continuation of Current Smart Grid Roadmap objective in Updated Smart Grid Roadmap
	Objective was not achieved in the Current Smart Grid Roadmap but should be adopted in the Updated Smart Grid Roadmap

2.4 Other Developments in Viet Nam Relevant to Smart Grid Development

2.4.1 Viet Nam Power Development Plan 8 (PDP8)

The PDP8, under Prime Minister Decision No. 500/QD-TTg (15 May 2023), expects the power system to almost double in size by 2030 with total installed capacity reaching some 150 GW by 2030, and between 490.5 GW – 573.1 GW by 2050. Demand Growth is expected to continue to exceed 10% to the year 2030 and moderate to 3.8% from 2031 to 2050 – see Table 3. It should be noted that EV demand is included in the PDP8.

Table 3. Viet Nam Historical National Demand Growth and PDP8 Base Case Projection

Period	Demand	Growth Rate (CAGR) (%)
2015-22	Historical Demand Growth	7.38%
2023-30	PDP8 Base Case	10.24%
2031-50	PDP8 Base case Demand Growth	3.78%

PDP8 projects a shift from a coal-based mix towards renewables and the introduction of new technologies including battery energy storage, offshore wind, pumped hydro storage, hydrogen, and ammonia, which is driven by the country's commitment to reach net zero by 2050. While presently rooftop solar is focused on self-consumption there is a target for rooftop solar penetration to reach 50% of all public office and residential buildings by 2030.

Key technologies that the Updated Smart Grid roadmap needs to consider are:

- Utility scale solar and rooftop solar being a very significant part of the generation mix,
- Onshore and offshore wind being a very significant part of the generation mix,
- Energy storage technologies providing for flexibility and power system stability,
- From 2030, transition coal-fired power stations to ammonia and/or biomass,
- From 2040, phasing out of coal-only generation resources, and
- Increased power imports from neighbouring power systems.

The PDP8 recognizes that Smart Grid technologies will need to play a role in supporting the energy sector transition. It also identifies "the renovation and upgrading of power transmission and distribution system, improving reliability and reducing power losses, and accelerating the roadmap to building a smart power grid" as an important solution for integrating stronger renewable energy resources.

2.4.2 Demand Response (DR)

In 2014 the Ministry of Industry and Trade (MOIT) issued Decision No. 2600/QD-BCT approving the plan to implement pilot demand response (DR) programs for period 2014 – 2015 assigning ERAV with the responsibilities of: (1) developing detailed design of pilot DR programs, and (2) development of incentive mechanisms required to implement the pilot programs. This has led to two main outcomes of relevance to the Updated Smart Grid Roadmap:

- Pilot DR Program at EVNHCMC, and
- Non-commercial DR programs.

The main outcome of the Pilot DR Program – implemented in 2014-15 was that the incentive mechanism was inadequate to create a strong incentive for participants in the program to respond.

The non-commercial DR programs attracted a higher total of 3,035 customers across all 5 PCs with electricity consumption of 1 million kWh per year or more and have signed agreements with the PCs to take part in non-commercial voluntary DR programs. The total potential reduction in demand of the participated customers is estimated at 1,552 MW. Based on 10 events under the non-commercial program the maximum demand reduction was 513.9 MW.

While both DR initiatives in Viet Nam have had some success, in the absence of a commercial incentive and pricing mechanisms to encourage and reward a responsive demand side, it is extremely challenging to create a strong incentive on customers to take measures to install Smart Grid technologies that will improve the flexibility of end-use devices and resources.

2.4.3 Demand-Side Management (DSM)

More generally, an observation from our review of smart grid development in Viet Nam was that there is a general lack of policies to encourage demand side participation and demand side management (DSM). This includes no technical regulations for energy storage systems, incentive mechanisms for smart grid applications in zero energy buildings, incentive mechanisms for smart grid applications in energy trade between customers and power companies, and incentive mechanisms for residential customers participation in DSM.

2.4.4 Viet Nam Wholesale Electricity Market (VWEM)

On 10 August 2015, the MOIT approved the Detailed Design of the Wholesale Electricity Market of VietNam (VWEM) under Decision No. 8266/QD-BCT. The decision applies to both the Pilot VWEM and the Full VWEM. The current VWEM that has been in operation since 1 January 2019 has allowed the PCs to participate in the market as wholesale buyers purchasing CfD PPAs from a limited number of generators.

The VWEM has not progressed towards achieving its intended design with key issues including the lack of Market Management Systems (MMS) and other required IT supporting infrastructure systems have not been procured and installed. Issues of note include:

- A significant portion of installed capacity (40%) does not directly trade in the power market and faces no exposure to the market mechanisms – including a proliferation of participants with FITs and physical PPAs that do not require participation in the market,
- Customer direct participation in the VWEM has not occurred, although a pilot to trial direct PPAs (between RE developers and customers), as effectively CfDs, has commenced in 2021, which may evolve if deemed successful,
- A limited amount of contract trading directly between DTGs and PCs commenced in 2020, and it was expanded in 2021, although it accounts for no more than 10% of the total market, and
- Bilateral contracting arrangements (in addition to the current SPPAs) have not been finalised,
- There are no demand-side bidding and no ancillary service markets, and
- There are no rules or mechanisms for energy storage participation in the market.

The progress on VWEM is important to note for Smart Grid Roadmap because the market could be a driver for more efficient operation which in turn creates a stronger incentive on participants to market investments in smart grid technologies.

2.4.5 Viet Nam Retail Electricity Market (VREM)

On 7 August 2020 the MOIT approved ERAV proposal for VREM model design which includes an implementation plan of the Viet Nam retail market (Decision No. 2093/QD-BCT). The proposed VREM implementation plan considers the following stages:

- First stage (up to the end of 2021) focusing on necessary preparatory works including issuance of required regulations,
- Second stage (from 2022 to 2024) allowing end users to purchase power directly from the spot market,
- Third stage (after 2024) allowing gradually end users to choose their preferred retailer.

As of December 2023, the VREM has not progressed according to this proposed plan as many prerequisites are yet to be met and no VREM legal document has been issued for implementation.

As with the VWEM, the VREM not being fully implemented is an impediment to creating incentive on PCs to offer dynamic pricing products to consumers and hence encourage a more responsive demand-side. As noted, this has been an impediment to DR program implementation.

2.5 Other Identified issues for Updated Smart Grid Roadmap

2.5.1 Governance

MOIT needs stronger support and collaboration from other relevant Ministries and agencies, such as the Ministry of Finance, Ministry of Science and Technology, Ministry of Construction, Ministry of Transport. The rationale for close partnerships between different sectoral agencies is that new Smart Grid concepts and applications require careful research and expertise exchanges among the impacted parties before appropriate sectoral policy mechanisms can be made. The general roles of the ministries are summarized in Table 4. In relation to the Smart Grid Roadmap of 2012 the ministries are required to form a working group to meet regularly as part of monitoring and collaborating where necessary on the implementation of the Smart Grid Roadmap.

Table 4 Ministries and Role

Ministry	Role
Ministry of Industry and Trade (MOIT)	- Responsible for the advancement, promotion, governance, regulation, management and growth of industry and trade. - Within the MOIT, ERAV is responsible for development of Smart Grid Roadmap and programs, and mechanisms including regulatory arrangements to support implementation. - Entities in the power sectors including EVN NLDC, NPT and the PCs are responsible for implementation of the Smart Grid programs.
Ministry of Finance (MOF)	Responsible for implementation of the State's financial policies and would be in charge of approving state financial funds, financial investment for Smart Grid programs.
Ministry of Science and Technology (MOST)	- Responsible for state administration of science and technology activities; development of science and technology potentials. - Development and publication of technical and metrological standards for equipment, systems and procedures. - Providing inputs to the SG working group in relation to the areas of responsibility.

Ministry	Role
Ministry of Construction (MOC)	- State administration on construction, building materials, housing and office buildings, architecture, urban and rural construction planning, urban infrastructure, public services. - Providing inputs to the SG working group in relation to the areas of responsibility. - Implementation of the SG Roadmap and programs in relation to the sector.
Ministry of Transport (MOT)	- Responsible for governing rail transport, road transport, water transport, maritime transport, and air transport in Vietnam. - Providing inputs to the SG working group in relation to the areas of responsibility. - Implementation of the SG Roadmap and programs in relation to the sector.

Additionally, the level of investment required for Smart Grid development is substantial, for which supporting policies and appropriate financial mechanisms are needed but still absent or unspecified. For example, the investment size of smart grid may range from 100 million USD to more than 1 billion[1] USD depending on the technologies considered, condition and size of the power system into which they are deployed. Design of financial incentive mechanisms with any implications on electricity prices will require policy inputs and backing from agencies such as the Ministry of Finance.

2.5.2 SCADA/EMS/DMS Rollout and Substation Automation

Despite the SCADA systems having been completely installed at the power plants and substations, the stability of SCADA connections and signal reception needs further improvement (at least 90% of stable SCADA data reception is required) for effective utilisation of all functions of the SCADA/EMS/DMS systems.

In terms of the transition to unstaffed, fully automated transformer substations, while necessary infrastructure and procedures have been set up, the existing fire prevention regulations still require grid entities to arrange 01 employees to be physically present at each substation for fire duty.

2.5.3 AMI Infrastructure

Assessment of the AMI pilot project implemented at HCMC has shown that rolling out many AMI meters for customers in a short time would increase supply costs and place pressure on electricity prices. Therefore, the roadmap for deployment of AMI systems needs to be reconsidered and adjusted accordingly. An example of how the costs can be brought down for AMI infrastructure is to define a staged rollout, competitively procure an AMI technology supplier who will roll the technology out in a staged fashion that can achieve an economy of scale.

[1] Sources: (1) Low Carbon Green Growth Roadmap for Asia and the Pacific FACT SHEET, "Smart Grid", website: https://www.unescap.org/sites/default/d8files/56.%20FS-Smart-Grid.pdf, (2) EPRI 2011 Technical Report, "Estimating the Costs and Benefits of the Smart Grid", website: https://smartgrid.gov/files/documents/Estimating_Costs_Benefits_Smart_Grid_Preliminary_Estimate_In_2011 03.pdf.

2.5.4 Incentives for Research and Development

While companies have proactively carried out research on product development, there has been a lack of incentive mechanisms and supporting industries, no commercial products have been widely introduced.

2.6 Implications for Updated Smart Grid Roadmap

Overall, the areas that the Study report on the status of smart grid development in Viet Nam identified as being major areas for the Updated Smart Grid Development Roadmap for Viet Nam to address are set out in the following subsections. These issues are set out in Table 5 and form the basis of the areas of Viet Nam's current Smart Grid Roadmap policies that need to be provisioned for in the Updated Smart Grid Roadmap that is presented in section 6.

2.6.1 Further modernization in monitoring and control of power system operations

Modernization of the monitoring and control systems for the operation of the power system is crucial in terms of laying down the foundation on which numerous other technologies and smart applications can be built on.

Issues that the Updated Smart Grid Roadmap must address in this area include:

- Completion of updating the SCADA/EMS/DMS systems for the NLDC and grid participants, maintaining stable connections and signal transmission to comply with the requirements of the power system and power market operations, and capable of supporting all EMS/DMS functionalities and integrating a larger amount of diversified RE sources.
- Continue to enhance the grid control and monitoring centers to achieve and maintain the 100% rate of fully automated unstaffed operations of all high voltage substations (110kV and 220kV).
- Modernize the medium-voltage power grids by increasing the proportion of the distribution grids equipped with remote control devices, integration of Fault Management and System Restoration (FMSR) and Advanced Distribution Management System (ADMS) system into SCADA to improve power supply reliability. Set an intermediate target of 50% medium-voltage substations to be remotely monitored and operated by 2030.
- Enhance communication protocols and the ability to link and exchange information between the NLDC, RLDCs and distribution grid control and monitoring centers.
- Geographic Information System (GIS): Set a target of 50% transmission and distribution network management units by 2030 to develop and implement GIS for power grid management.

2.6.2 Remote metering, smart metering, and data analysis

Recommendations from the Study report on the status of smart grid development in Viet Nam were as follows:

- Moving towards the deployment of 100% electronic meters with remote measuring capabilities across the entire power grid, with an intermediate target of 95% by 2030. No new mechanical meters shall be installed.
- Gradually implement AMI and smart meters (featuring two-way interactions) for customers in accordance with operational, commercial and customer service requirements while ensuring economic efficiency.

- Rolling out smart devices capable of supporting Demand Response programs.
- Gradually apply artificial intelligence and data analytics in monitoring, energy consumption and demand forecasts, equipment condition assessment and system fault forecasting.

2.6.3 Integration of distributed energy resources (DER)

Recommendations made by the Study report on the status of smart grid development in Viet Nam related to DER were:

- Develop the Distributed Energy Resources (DER) Management System at the NLDC, RLDCs and Distribution Companies.
- Development of a TSO/DSO coordination model for managing distributed resources.
- Gradually integrate energy storage systems to optimize mobilization and operation of distributed sources. Experiment small-scale energy storage modules to balance supply and demand at the end-user level.
- Investigate the potential for implementing microgrids in important load locations, remote areas, and islands; microgrid systems that integrate battery storage systems and smart electric vehicle charging stations.
- Examine new operational management models for amalgamation of many distributed energy resources, such as virtual power plants.

2.6.4 Eliminate barriers to the introduction of new energy resources, renewable energy (RE) and energy efficiency (EE)

The following is recommended in the Study report on the status of smart grid development in Viet Nam:

- Continue to encourage the development of new energy renewable energy sources for self-consumption to reduce the pressure of additional investments for power networks expansion.
- Implement programs for energy efficiency, demand management and demand response.
- Explore tools and solutions for managing electric vehicle charging stations and their integration into the demand management systems of the power companies to help achieve the overall effectiveness of the electrical system.

2.6.5 Targets and Actions not Yet Complete

The targets and actions that have yet to be satisfied from prior legislation have been reviewed and all are important to carry forward in the Updated Roadmap with time frames indicated in Table 1 and Table 2.

3 Roadmap Requirements based on Review of Smart Grid Technologies

3.1 Purpose

This section briefly summarizes the findings of our reviews on the status of smart grid development in Viet Nam and on Smart Grid technologies and international experience, with a view to canvassing smart grid technologies that need consideration in Viet Nam's Updated Smart Grid Roadmap.

3.2 Defining "Smart Grid"

A "Smart Grid" is an electrical network that can cost efficiently integrate behaviours and actions of all users connected to it such as generators, transmission network service providers, distribution network service providers, consumers, and prosumers, to ensure an economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety.

Smart Grids employ a range of innovative technologies and services in combination with intelligent monitoring, control, communication, and self-healing technologies to:

- Better facilitate the connection and operation of generators of all sizes and technologies,
- Allow consumers to play a part in optimizing the operation of the system,
- Provide consumers with greater information and options for how they use their supply,
- Significantly reduce the environmental impact of the whole electricity supply system,
- Maintain or even improve the existing high levels of system reliability, quality and security of supply, and
- Maintain and improve the existing services efficiently.

A common element to most definitions of Smart Grid is the application of digital processing and communications to the power grid, making data flow and information management central to the smart grid. Various capabilities result from the deeply integrated use of digital technology with power grids; hence it is important to have a suitable digital strategy in place.

3.3 Smart Concepts & Technologies

Figure 2 and Figure 3 show examples of conceptual smart energy networks and smart grid enabling technologies:

Figure 2. Conceptual Smart Networks

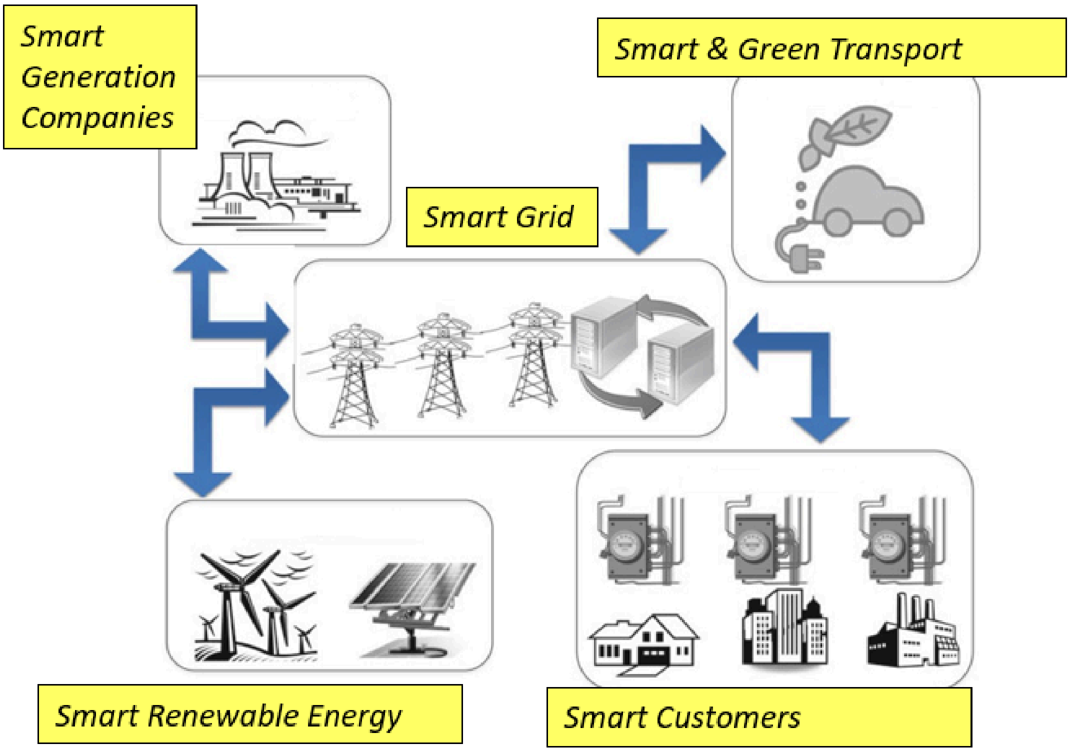
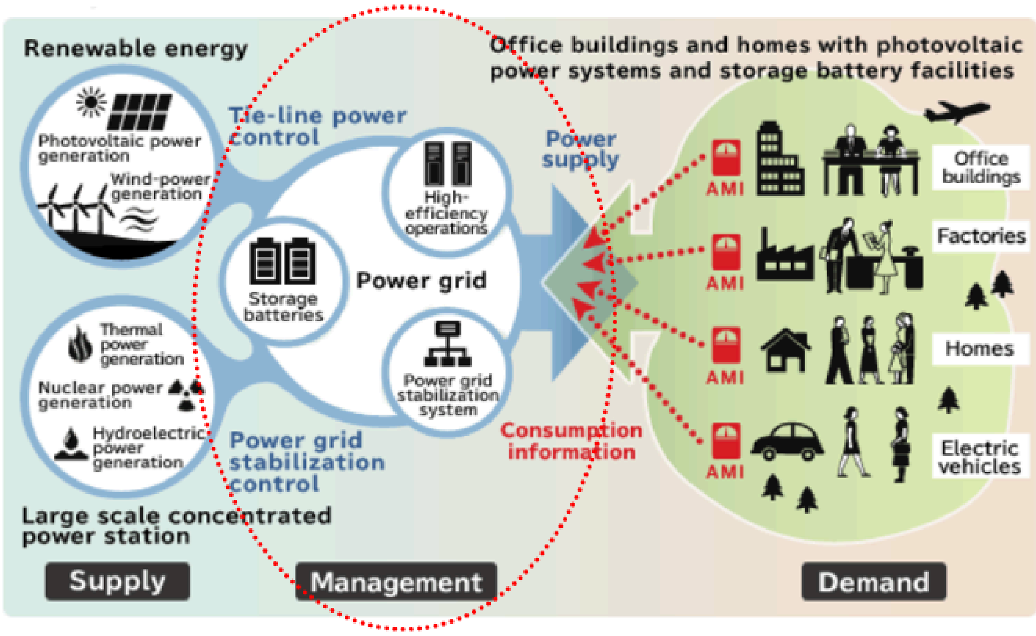


Figure 3. Smart Grid Enabling Technology[2]



Smart technologies may be involved with the following components across different segments of a power grid:

- SCADA / EMS / DMS

[2] Source: https://www.hitachi.com/sustainability/highlight/2010/act1003/index.html

- Telecommunications Infrastructure
- Substation Automation Systems (SAS)
- Wide Area Monitoring System (WAMS)
- Static Var Compensators (SVC)
- High Voltage Direct Current (HVDC)
- Fault Locator System (FLS)
- Dynamic Thermal Circuit Rating
- Geographic Information Systems (GIS)
- Metering Data Acquisition System (MDAS)
- Advanced Metering Infrastructure (AMI)
- Smart Meters
- Security Constrained Economic Dispatch (SCED)
- Data warehouses & data management systems

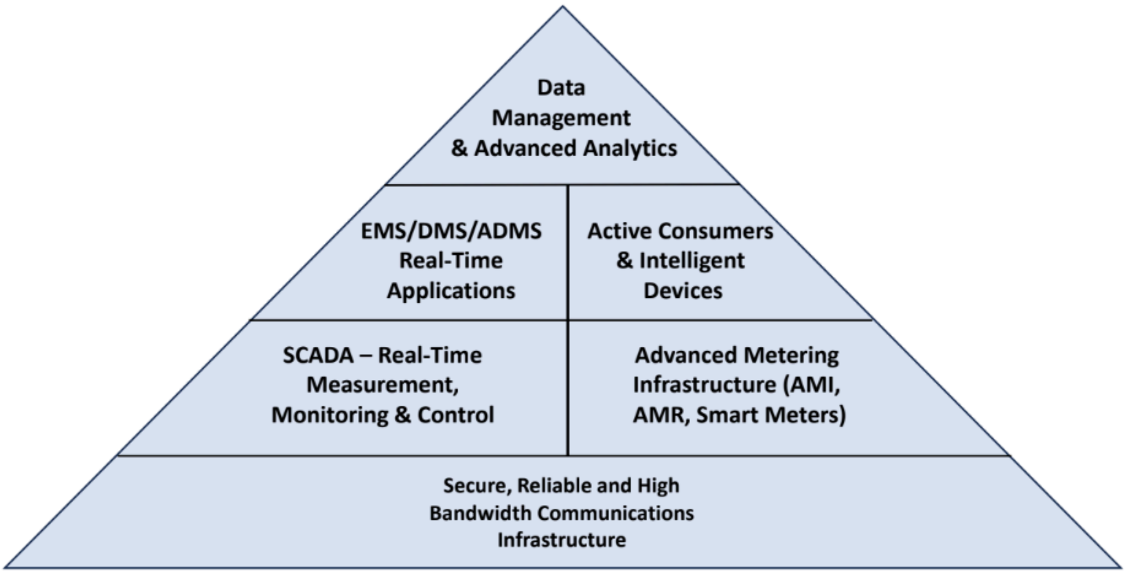
3.4 Technology Pillars to Support Smart Grid Roadmap

The key pillars of Smart Grid can be divided into the following general areas:

- Secure and reliable communications infrastructure.
- Metering infrastructure, supporting intelligent devices and active customers,
- SCADA platforms with EMS, DMS and ADMS applications, and
- Data management and analytical systems

Ordered approximately from the most foundational to the least foundational as shown in Figure 4.

Figure 4. Technology Pillars to Support Smart Grid Roadmap



The illustration is organized so that the generation and transmission side of the industry and associated technologies are to the left, while the customer and distribution technologies are generally on the right, while both rely on communications infrastructure to support data transfers and the data management layer brings together all technologies in a unified platform.

3.5 Generation Technologies

Smart Grid technologies associated with generation technologies include the following:

- Smart Inverters,
- Advanced Forecasting Systems for Variable Renewable Energy,
- Utility scale Battery Energy Storage Systems (BESS)[3],
- Support for Virtual Power Plants (VPPs)[4] – where aggregation of many individual distributed resources such as batteries and renewable energy can have their injected power managed in the grid to provide ancillary services (such as correcting frequency and voltage imbalances), respond to local disruptions or disturbances, and keep networks stable.

3.6 Transmission Technologies

Smart Grid technologies associated with generation and transmission technologies include the following:

- Management of intelligent / smart grid technologies such as Flexible AC transmission devices and HVDC links (if required),
- Efficient use of the Transmission network, also achieved through real-time optimisation of generation and transmission network,
- Ensuring power system security through the accurate calculation of security margins in real time, based on real-time power flow analysis, this in turn ensures reliable supply through HV transmission systems,
- Real-time management of variable renewable energy resources,
- Outage Management Systems (OMS) to manage the outage plans of generation and transmission equipment,
- Management of ancillary services providers – including automatic frequency regulation, and sources of contingency reserves,
- Dynamic Line Ratings (DLR),
- Phasor Measurement Units (PMUs),
- Wide Area Monitoring System (WAMS) – which operates as a warning technology to help prevent system overloading, instability, and cascade tripping resulting in blackouts. WAMS applications require latency in the range of 100ms to 5s. PMUs are generally a precondition for WAMS as they rely on accurate and synchronised measurements from grid equipment.
- Asset management systems, and
- Static VAR Compensators.

[3] While BESS is technically also a demand-side resource, utility-scale BESS is normally considered within the same framework as conventional generation technologies.

[4] While VPPs usually aggregate distribution level resources, they are treated within the same framework as conventional generation technologies.

3.7 Distribution Technologies

Smart Grid technologies relevant to the distribution sector include:

- Advanced Distribution Management Systems (ADMS) which create an integrated view of the distribution operations by interacting with other operational systems like GIS, OMS, and CIS. ADMS can gather, organize, display, and analyse real-time distribution system information across several platforms and supports grid operations.
- Fault Location, Isolation and Service Restoration (FLISR) is a software application and set of field devices that automate distribution operations to enable the detection and fast response (in seconds) to restore power to customers in response to grid events, such as storm-induced outages. FLISR systems include line sensors, automatic switches or reclosers, communication networks, and a control system.
- Substation Automation Systems where automation is done for monitoring, controlling, and collecting data from substations which will reduce the duration of interruptions caused due to equipment failures, natural catastrophes, and outages at substations.
- A distributed energy resource management system (DERMS) is a software application that provides an operator with real-time visibility into the state of distributed energy resources (DERs) and the controls required to integrate and optimize DERs in support of grid operational objectives.

3.8 Customer Technologies

The fourth area of grid modernisation is electricity consumers and aggregators who use energy management systems in residences, commercial buildings, and manufacturing facilities. This includes:

- Advanced Metering Infrastructure (AMI) – including Automatic Meter Reading (AMR) systems and Meter Data Management Systems (MDMS), and fitting consumers with smart meters,
- Active pro-summers, supporting for example, feeding into the grid from households that have installed solar PV and small-scale BESS,
- Electric Vehicle (EV) charging infrastructure,
- Demand response schemes for lower voltage customers,
- Intelligent control of appliances and end-use equipment through smart meters and supporting infrastructure,
- Automated home systems, intelligent appliances, and building automation/building management system, and
- Internet of things, to manage devices and other end-use appliances via the internet.

3.9 Communications infrastructure

The communication infrastructure includes cellular, lease-lines, dedicated LANs, and WANs in terms of the key hardware elements. It also includes communication servers and routers, and other supporting computing infrastructure that enables data exchange to happen and that support the required amount of bandwidth for the industry.

Associated technologies include firewalls, blockchain protocols, data servers, data exchange protocols and other supporting technologies. These are leveraged to enable reliable and secure data transfers between the different participants in the electricity sector.

The main communication technologies that are often considered as part of a Smart Grid include:

- Wide Area Network (WAN) serves as the communication network's backbone in the power grid. It connects smaller distributed networks to utility firms' control centres, such as transmission substations, control systems, and protection equipment, such as Supervisory Control and Data Acquisition (SCADA), Remote Terminal Unit (RTU), and Phasor Measurement Unit (PMU).
- Neighbourhood Area Networks (NAN) and Field Area Networks (FAN) are distribution domain networks that allow information to flow between WAN and a Premise Area Network (HAN, BAN, IAN). The NAN connects neighbourhood premises networks via smart meters at the end-user.
- Depending on the environment, the Premise Area Network is divided into three sections: HAN (Home Area Network), BAN (Building Area Network), and IAN (Industrial Area Network). These are wired or wireless networks that are located on the end-user's premises.

3.10 Data Management Systems and Analytics

Data management systems are critical to improving monitoring and transfer / sharing of critical information between all users of the power system. Utilities often need to establish data warehouses and set up data exchange protocols to support the exchange of information between participants. A key aspect of this is to integrate the data from a variety of sources into a uniform platform or set of platforms. Establishing standardised portals and data exchange standards will facilitate the transfer of data and information between different entities in the electricity industry.

In future it could be expanded to include cloud computing services and applications that are transitioned into the cloud to enable distributed computing and shared applications. This is a trend that is emerging in the power sectors of many jurisdictions worldwide.

The main types of technologies that are included under Smart Grid include:

- Advanced Analytics (AA) and Artificial Intelligence (AI): SGs equipped with sensors and smart equipment capture operational data in digital format. The big data collected can be used to provide insights into asset performance and customer electricity consumption resulting in efficient network planning and capital expenditure for utilities. AA and AI help utilities improve operational efficiency by acting beforehand thus improving the grid.
- Geographic Information Systems (GIS) which maps all the electrical assets with indexes on all customers. This enables the electricity utility to plan and manage its operations accordingly.
- Cloud computing and containerisation: Utilities are increasingly moving towards the use of cloud computing. Cloud computing is the practice of using a network of remote servers hosted on the internet to store, manage, and process data, as opposed to using a local server or a personal computer. It provides access to shared computer processing power via the internet and is usually high performance. Examples include Azure Blob Storage, Docker (open-source container-based solution), Kubemetes / AKS, Key Vault (Azure), SQL Server, Cosmos DB, Apache Kafka, and Cucumber / Specflow (BDD / Automated testing).
- Edge computing: which is when servers physically near to the user are located to reduce latency and improve performance of virtual computing. Edge Server is a bit like a small-scale cloud data centre that is in closer proximity to users of the service, which can run applications programs with reduced latency and be more reliable.
- Blockchain: Blockchain is a distributed ledger technology built on shared network infrastructure and public key encryption to provide secure transactions through smart contracts. Blockchain-based technologies can be applied at utilities in energy credit

management, scaling up of distributed energy resources, asset optimisation, peer to peer (P2P) transactions, etc.

3.11 Smart Grid Technologies Piloted or Tested in Viet Nam

According to a GIZ report entitled “Smart Grids Technology Assessment for Renewable Energy and Energy Efficiency” conducted by GIZ in 2022[5], key technologies that have been widely applied in the Viet Nam’s power system include:

- SCADA/EMS system which has been upgraded and extended to all power plants with the capacity of over 30 MW, and installed for Power Corporations,
- Dissolved Gas-in-oil Analysis (DGA) − equipped for all 500 kV transformers and important 220 kV transformers,
- Outage Management Systems (OMS) − set up in most Power Corporations with the DMS integration, and
- Automatic Meter Reading (AMR) − successfully deployed for the Power Corporations’ most customers.

And technologies that have been identified to have been deployed on a small scale or implemented as pilot projects, include:

- Equipping Substation Automation Systems (SAS) for 110kV substations,
- Wide Area Monitoring System (WAMS) established and connected with several 500 kV substations,
- Lightning Location System (LLS) established with 9 sensors in various regions,
- Fault Locator Systems (FLS) or Fault Location, Isolation and System Restoration (FLISR) systems are made available at some Power Corporations,
- Dynamic Thermal Circuit Rating (DTCR) as trials,
- AMI and Smart Meters were conducted as a pilot project in Ho Chi Minh City Power Corporation.

3.12 Implications for Upgraded Smart Grid Roadmap

The key conclusion to this section is to address the question of what technologies should be deployed in Viet Nam and what aspects need to be established. These issues are set out in Table 5 and forms the basis for technologies that the Smart Grid Roadmap provisions for in section 6. The table indicates the priority of each identified technology with respect to when the technology will be required under Vietnam’s PDP8 and other policy initiatives.

Note that a list of potential technical standards that should be considered was provided in the Study Report on Smart Grid Technology and International Experience report Appendix.

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5 chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.giz.de/en/downloads_els/Smart%20Grids_ENG_25-6.pdf

Table 5. Smart Grid Technology Assessment for Viet Nam and Requirements for Updated Smart Grid Roadmap

Industry Area	Technology	Deployment Status in Viet Nam	Policy Target Exists?	Technical Standard in Place?	Needed by when?		Included in the Updated Smart Grid Roadmap?	Priority (in 2024)	Approach Recommended for Smart Grid Roadmap
					2030	2050			
Generation Technologies	Smart Inverters	Limited	No	No	Yes	Yes	Yes	High	Directive to develop inverter policy and standard.
	Utility-Scale Solar Forecasting	Limited deployment & integration	No	No	Yes	Yes	Yes	High	Directive to integrate into central dispatch and introduce forecast accuracy standards.
	Rooftop Solar Monitoring & Forecasting Systems	Generally, in place	Yes	No	Yes	Yes	Yes	High	Directive to integrate into central dispatch and introduce forecast accuracy standards.
	Onshore wind forecasting system	Limited deployment & integration	No	No	Yes	Yes	Yes	High	Directive to integrate into central dispatch and introduce forecast accuracy standards.
	Offshore wind forecasting system	None	No	No	Yes	Yes	Yes	Medium	Directive to integrate into central dispatch and introduce forecast accuracy standards.
	Utility Scale Battery Energy Storage Systems	Pilot only	No	No	Yes	Yes	Yes	High	Directive to integrate into central dispatch and introduce forecast accuracy standards. Energy storage regulations need to be developed.

Industry Area	Technology	Deployment Status in Viet Nam	Policy Target Exists?	Technical Standard in Place?	Needed by when?		Included in the Updated Smart Grid Roadmap?	Priority (in 2024)	Approach Recommended for Smart Grid Roadmap
					2030	2050			
	VPPs	Not deployed	**No**	**No**	**No**	Yes	Yes	Low	Directive to develop legal and regulatory framework after 2030.
	Synchronous Condensers	Not widely deployed or used	**No**	Partially in Grid Code	**No**	Yes	Yes	Medium	A potential application for repurposed fossil fuel plant is to convert to synchronous condensers to ensure system stability – it is recommended that there be a general directive to supporting this[6].
Transmission Technologies	FACTS / HVDC	Not deployed	**No**	**No**	**No**	Possibly	Yes	Medium	Recommend having a vision to accommodate HVDC and FACTS in the long-term
	Real-time optimisation of transmission network capability and security constraints	Limited deployment in central dispatch	**No**	**No**	**No**	Yes	Yes	High	Improved centralised dispatch mechanism to fully utilise transmission network capacity – required to better support decentralised energy resources
	OMS (at transmission level)	In place	**No**	Yes	Yes	Yes	**No**	N/A	It has already been deployed fully at NLDC within the context of existing SCADA/EMS. It is not

[6] It is arguable whether this is really a Smart Grid application, however, to support the uptake in renewable energy envisaged in the PDP8 and coal phase-out from 2040, having a framework to support this more generally will be important.

Industry Area	Technology	Deployment Status in Viet Nam	Policy Target Exists?	Technical Standard in Place?	Needed by when?		Included in the Updated Smart Grid Roadmap?	Priority (in 2024)	Approach Recommended for Smart Grid Roadmap
					2030	2050			
									necessary to explicitly include in the Updated SG Roadmap.
	Dynamic Line Ratings (DLR)	Piloted	No	No	Yes	Yes	Yes	High	Full deployment of technology by 2030 is recommended – target is recommended.
	WAMS / PMUs	Piloted for some 500 kV networks	No	No	Yes	Yes	Yes	Medium	Scale up deployment for 500 kV network by 2030 and subsequently 220 kV (beyond 2030). Target and vision is recommended.
	Static VAR Compensators	Deployed and used	No	Yes	Yes	Yes	No	N/A	This is standard transmission planning and does not need to explicitly be added to the Smart Grid Roadmap.
	Distributed Energy Resource management system (DERMS)	Not deployed but key DERs are monitored	No	No	Yes	Yes	Yes	Medium	Large DERs and aggregations of small DERs by network location should be made available to NLDC in real-time via interfacing to PCs' DERMS.
	GIS Networks and Real-Time Status Display for transmission network assets	Not deployed	No	No	Yes	Yes	Yes	High	Wider deployment of GIS technologies should be included as a general directive for control rooms of NLDC and RLDCs.

Industry Area	Technology	Deployment Status in Viet Nam	Policy Target Exists?	Technical Standard in Place?	Needed by when?		Included in the Updated Smart Grid Roadmap?	Priority (in 2024)	Approach Recommended for Smart Grid Roadmap
					2030	2050			
Distribution Technologies	OMS (at distribution level)	In place but not fully deployed	**No**	Yes	Yes	Yes	Yes	High	Full deployment across PCs via DMS is recommended by 2030. It is understood to not be the case.
	GIS Networks and Real-Time Status Display for distribution network assets	Not deployed	**No**	**No**	Yes	Yes	Yes	High	Wider deployment of GIS technologies should be included as a general directive for control rooms of NLDC and RLDCs.
	Fault Location, Isolation and Service Restoration (FLISR)	Piloted	**No**	**No**	Yes	Yes	Yes	High	Pilot should be scaled up to full deployment at each PC, initially at medium-voltages and eventually to lower voltage levels where it makes sense.
	Substation Automation Systems (SAS)	Significant progress has been made	Yes	Yes	Yes	Yes	Yes	High	Original targets can be increased and with a target to achieve by 2030. Medium Voltage SAS targets can be introduced.
	Distributed Energy Resource management system (DERMS)	Not deployed	**No**	**No**	Yes	Yes	Yes	Medium	Directive to establish DER standards and take measures for monitoring of DER at distribution network level. This needs to be coordinated

Industry Area	Technology	Deployment Status in Viet Nam	Policy Target Exists?	Technical Standard in Place?	Needed by when?		Included in the Updated Smart Grid Roadmap?	Priority (in 2024)	Approach Recommended for Smart Grid Roadmap
					2030	2050			
									with NLDC for large DER resources.
	AMR and MDMS for meter reading	Significant progress has been made but full deployment not achieved yet	Yes	Yes (Metering Code)	Yes	Yes	Yes	High	Complete the roll out of AMR/MDMS rollout.
Customers	Advanced Meters / Smart Meters	Some piloting and trials of smart meters	Yes	Yes (Metering Code)	**No**	Yes	Yes	Low	This has proven to not be very cost effective, and the implementation of a retail market has stalled making it difficult. The recommendation is to have this in the longer-term, contingent on Retail Market and Dynamic Pricing.
	EV Infrastructure and mechanisms	Limited	**No**	**No**	Yes	Yes	Yes	Medium	Directive to establish an enabling framework for EVs in the electricity sector.
	V2G Mechanisms	None	**No**	**No**	**No**	Yes	Yes	Low	Long-term vision should be integrated of vehicles to provide grid services or be leveraged (on voluntary basis) by VPPs

Industry Area	Technology	Deployment Status in Viet Nam	Policy Target Exists?	Technical Standard in Place?	Needed by when?		Included in the Updated Smart Grid Roadmap?	Priority (in 2024)	Approach Recommended for Smart Grid Roadmap
					2030	2050			
	DR schemes / mechanisms for LV customers	Limited / Pilots	Yes	Yes (Distribution Code)	Yes	Yes	Yes	High	Continuation of DR, although it is recognised that the absence of incentives via dynamic pricing or an explicit incentive scheme for this is a major impediment.
	Support for Intelligent End-Use Devices	Limited with Pilots	**No**	**No**	**No**	Yes	Yes	Low	Recommended to be considered as part of the longer-term vision for Smart Grid development.
	Support for Automated Home Systems	Limited	**No**	**No**	**No**	Yes	Yes	Low	Recommended to be considered as part of the longer-term vision for Smart Grid development.
	Support for Building Energy Management Systems	Not deployed	**No**	**No**	Yes	Yes	Yes	High	Legislative framework to support this needs to be established as a priority.
Communications Infrastructure	WAN	Yes	Yes	Yes	**No**	**No**	Yes	High	Already provisioned for, however, continuous improvement and adaptation to changing circumstances should be factored into the SG Roadmap.

Industry Area	Technology	Deployment Status in Viet Nam	Policy Target Exists?	Technical Standard in Place?	Needed by when?		Included in the Updated Smart Grid Roadmap?	Priority (in 2024)	Approach Recommended for Smart Grid Roadmap
					2030	2050			
	NANs, FANs, PANs	None	**No**	**No**	**No**	Yes	Yes	Medium	Recommendation is to have a general directive to formulate standards to support this.
	HANs, BANs, IANs	None	**No**	**No**	**No**	Yes	Yes	Low	Recommendation is to have a general directive to formulate standards to support this.
Data Management Systems and Advanced Analytics	AA and AI tools	None	**No**	**No**	Yes	Yes	Yes	High	General directive to explore the use of this technology to improve performance of power system operations including its monitoring and control.
	Cloud Computing	Limited	**No**	**No**	**No**	Yes	Yes	Medium	General directive to encourage movement towards leveraging cloud-based computing services where it enhances efficiency.
	Edge Computing	None	**No**	**No**	**No**	Yes	Yes	Low	General directive to encourage movement towards leveraging Edge-Computing where it enhances efficiency.
	Blockchain	Limited	**No**	**No**	**No**	Yes	Yes	Low	General directive to encourage movement

Industry Area	Technology	Deployment Status in Viet Nam	Policy Target Exists?	Technical Standard in Place?	Needed by when?		Included in the Updated Smart Grid Roadmap?	Priority (in 2024)	Approach Recommended for Smart Grid Roadmap
					2030	2050			
									towards leveraging blockchain where it makes sense.
Cyber Security	Ensuring industry-wide security standards across Smart Grid applications	Limited	**No**	**No**	Yes	Yes	Yes	High	Given the importance of cyber security to ensure successful Smart Grid operations directives need to be included in the SG Roadmap to ensure this is addressed. Further discussion of Cyber Security is set out in section 5.

4 Roadmap Requirements based on International Smart Grid Experience

4.1 Purpose

The purpose of this section is to summarise the key findings from our review on international practices in Smart Grid and to set out the implications for the Updated Smart Grid Roadmap.

4.2 Viet Nam's Performance Benchmarking in Smart Grid Technology Deployment

The report on the status of smart grid development in Viet Nam presented performance benchmarking of Viet Nam against comparator countries provided in the GIZ study: "Smart Grids Technology Assessment for Renewable Energy and Energy Efficiency" conducted by GIZ in 2022[7]. This assessment was implemented using the Smart Grid Index methodology that was introduced by SP Engineering Council, SP Group, Singapore.

The SP Group methodology defines the seven dimensions of Smart Grids, including Monitoring and Control, Data Analytics, Supply Reliability, Distributed Energy Resources (DER) Integration, Green Energy, Cybersecurity and Customer Empowerment and Satisfaction.

The GIZ study has also introduced an additional index which is "Energy Market" to provide guidance for evaluation of Viet Nam's smart grid readiness for a transition from the current wholesale energy market stage to the anticipated retail market stage. More details of these Smart Grid Indexes are shown in Figure 5.

Figure 5. Smart Grid Indices (based on SP Group SGIs)

The GIZ study's outcomes in the following table show that the smart grid development indexes for Viet Nam (in percentage) remain considerably lower than those of the countries under comparison, including South Korea, Japan, Australia, USA, and the UK. This implies that there are substantial venues in the Vietnamese power system for future deployment of smart grid technologies and applications. The acceleration of smart grids development in the country will require having an updated roadmap together with robust policies and regulations set in place, which will in many ways contribute to promoting energy transition through integration of more renewable energy resources.

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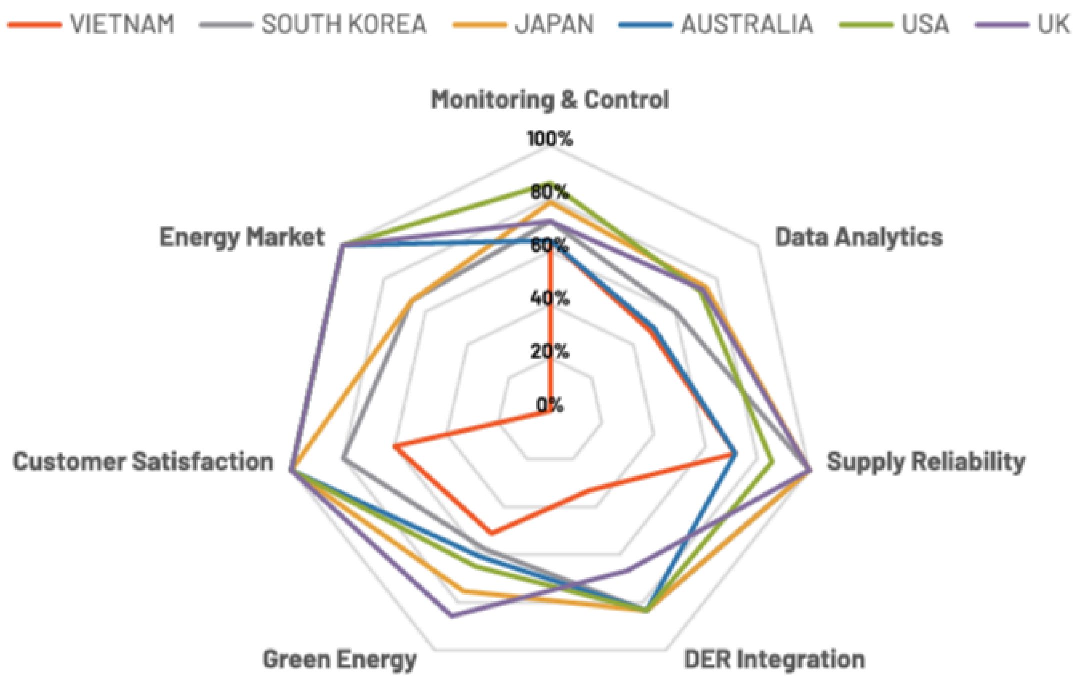
7 chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.giz.de/en/downloads_els/Smart%20Grids_ENG_25-6.pdf

Table 6. Smart Grid Development Indices: Viet Nam vs. Selected Countries

Index / Dimension	Viet Nam	South Korea	Japan	Australia	USA	UK
Monitoring & Control	64%	71%	79%	64%	86%	71%
Data Analytics	48%	60%	75%	50%	72%	73%
Supply Reliability	71%	100%	100%	71%	86%	100%
DER Integration	33%	83%	83%	83%	83%	67%
Green Energy	51%	57%	75%	61%	65%	86%
Customer Satisfaction	60%	80%	100%	100%	100%	100%
Energy Market	0%	67%	67%	100%	100%	100%
Final Score	***47%***	***74%***	***83%***	***76%***	***85%***	***85%***

Figure 6. Comparison of SG Development Indices between Viet Nam and Selected Countries



4.3 General Lessons from Review of International Experience

The Study Report on Smart Grid Technology and International Experience summarized experience with SG technologies and their roll out in Australia, the United States, United Kingdom, and Europe generally. It drew the following general lessons from having reviewed the implementation of Smart Grid Roadmaps:

- Existence of wholesale and retail electricity markets and in particular dynamic and cost-reflective pricing create incentives for the deployment of Smart Grid technologies because they improve efficiency, reduce costs, and allow resources to be more flexible in response to changing prices. Furthermore, market mechanisms for ancillary services can further strengthen the incentives and create opportunities for roll out SG technologies. For example, in Australia, VPP, DER and the existence of wholesale and retail electricity markets generally create such incentives.

- Introduction of standards ahead of rolling out new technologies is important. The lack of common standards can cause interoperability issues which limit the benefits of technologies or add overheads to technology integration efforts. Smart Meter roll out in the EU was extensive, but the lack of common standards became problematic in terms of data collection because of the lack of standardisation in communication protocols.
- Smart Grid strategy or vision is important to define objectives, targets, and linking the roadmaps to key performance indicators to facilitate the monitoring of progress. Once a holistic strategy or vision is in place, it is possible to develop implementation plans for subsystems and devices that can proceed in a staged manner consistent with the strategic objective.
- Integration of systems is a key success factor. For example, FLISR is more effective when implemented as part of an ADMS and integrated with a GIS. There is no single solution that is best for all circumstances. From a network topology perspective, FLISR is effective when deployed in a network that is intermeshed to allow rerouting of paths to resolve outages.
- Centralised versus Distributed Architecture: Similarly, the choice of central versus distributed control depends on the situation. Distributed architectures have become more dominant in SAS. Data requirements is also a key consideration. Solutions with heavy data requirements, such as PMU, are not effective if the communication infrastructure cannot support such needs.
- Ensuring interoperability between devices and systems was observed as a key success factor. Careful selection of standards is an important consideration to ensure the different parts of the system can work collaboratively. Managing current or legacy systems is an important part of implementation.
- Ensuring regulatory certainty in the face of a continuously changing technology landscape. Jurisdictions reviewed in Study Report on Smart Grid Technology and International Experience report have implemented, and continue to implement, regulatory reforms to fairly value and compensate services provided by participants. Appropriate regulation is crucial in ensuring DER participates broadly in a two-way system and market for services. Some markets, such as markets for demand response or for ancillary services by aggregated small resources, were developed to allow high levels of participation. This was done following trials and demonstrations were carried out that furnished information about the capability of such systems and market design options to accommodate and integrate these resources.
- Funding and financing mechanisms are important to have in place to adequately propel investment. The reviewed jurisdictions have implemented a combination of government and private funding of projects. Clear criteria for selection strongly linked to policy objectives should be established. Clear responsibility for selecting and administering projects have been key features that should be considered for adoption in Viet Nam. Finally clear performance and reporting obligations should be set.
- Privacy and ownership of data are also key issues that have been a common thread in the reviewed jurisdictions. It is important to set the right framework to encourage competition and make it easy for consumers to switch providers.
- Stakeholder consultation and involvement is a cornerstone of successful implementations. This has been accomplished in international implementations by involving stakeholders in all

stages of the process and projects through submissions to consultations, information sessions, participation in trials, demonstrations, research projects and committees.

4.4 Implications for Updated Smart Grid Roadmap

Based on benchmarking Viet Nam against comparison countries, the following areas are high priority for the Updated Smart Grid Roadmap:

- Completing and fully satisfying targets for real-time monitoring and control,
- Improving data analytics,
- Facilitating the integration of DER into the power system,
- Supporting green energy – with the most pressing technologies being solar, onshore and offshore wind, energy storage, electric vehicles and demand-side management,
- Energy market reforms to create stronger incentives on smart grid.

Key findings and outcomes from the wider integrational review were:

- Providing regulatory certainty,
- Data management and security,
- Supporting data analytics,
- Expect and plan for the interoperability of different types of technologies,
- Identifying suitable standards ahead of widespread deployment of a given SG technology,
- Improving data analytics, and
- Forming a holistic vision to guide the SG Roadmap.

These factors are inputs into the Updated Smart Grid Roadmap presented in section 6.

5 Roadmap Requirements based on Cyber Security

5.1 Purpose

Smart Grids involve combining a range of ICT technologies together to form an overall system that aims to better link supply and demand sides of the industry with the goal being to create incentives for more efficient operations. Merging many technologies and numbers of entities together introduces new vulnerabilities and hence risks to security. The security risks are often characterised in terms of vulnerabilities and in terms of attacks.

An observation in the 2012 Smart Grid Development Roadmap is that the role and importance of cyber security and defining appropriate standards as a component of the roll out in Smart Grid technologies is not recognized. For Vietnam, the integration of cyber security in the Updated Smart Grid Roadmap is a key initiative.

5.2 Security Risks of Smart Grid

Smart Grids involve combining a range of ICT technologies together to form an overall system that aims to better link supply and demand sides of the industry with the goal being to create incentives for more efficient operations. Merging many technologies and numbers of entities together introduces new vulnerabilities and hence risks to security.

The security risks are often characterised in terms of vulnerabilities and in terms of attacks.

5.2.1 Vulnerabilities[8]

The following are examples of the most serious vulnerabilities that arise when Smart Grid technologies are established:

- **Customer security**: smart meters collect large volumes of data which is transported to the utilities, consumers, and service providers. This data includes private information of customers that may be used in malicious ways.
- **Higher numbers of intelligent devices**: A smart grid involves interconnected many intelligent devices which may provide entry points for a malicious actor to gain control of a network. Having so many distributed devices also makes the task of monitoring network intrusions very difficult.
- **Higher numbers of stakeholder**: The more individuals and organisations that become interconnected and operating within a Smart Grid environment, the more opportunities there are for malicious actors within the organisations to compromise Smart Grid systems.
- **Physical security**: Unlike the traditional power systems, smart grid networks have components that are outside the premises of the system operator, market operator and/or utility. This also increases the number of potential insecure physical locations and provides a higher level of vulnerability to physical access intrusions.
- **Outdated equipment**: Power systems have been in operation for far longer than the IT industry, hence it is inevitable that old equipment remains in service presenting a weakness to security.
- **Device-to-device communication in control systems trusting each other**: Having device-to-device communications in control systems is vulnerable to the problem of one

[8] Source: Fadi Aloula, A. R. Al-Alia, Rami Al-Dalkya, Mamoun Al-Mardinia, Wassim El-Hajj, "Smart Grid Security: Threats, Vulnerabilities and Solutions", International Journal of Smart Grid and Clean Energy, vol. 1, no. 1, September 2012.

device sending a false state to another device to make it behave in an undesirable manner or a dangerous manner. When home or building equipment is connected to a utilities network, there is the risk that an intruder could issue false signals to the device.

- **Use of Internet Protocol (IP) and commercial off-the-shelf hardware and software solutions**: Using IP based standards for smart grid communications brings many advantages in terms of compatibility between devices and components. However, it also means that all the vulnerabilities of IP-based networks apply to the power sector.

5.2.2 Attacks

Before describing the types of attacks that can occur, it is important to classify the types of actors that have an interest in performing attacks on ICT infrastructure[9]:

- Non-malicious attackers who view the security and operation of the system as an intellectual challenge and who have no intent on causing damage or harm,
- Consumers driven by vengeance and vindictiveness towards other consumers making them figure out ways to shut down their home's power,
- Terrorists who view the smart grid as an attractive target as it affects millions of people making the terrorists' cause and impacts felt across a wide cross-section of society,
- Employees (past or present) disgruntled or ill-trained employees causing unintentional errors, and
- Competitors attacking each other for the sake of financial gain.

The types of attack can be classified into three main categories[10]:

- Component-wise – where field components like an RTU or a Smart Meter is attacked via remote access for example and malicious control of the device is achieved,
- Protocol-wise – where communication protocols are reverse engineered and data within them is altered, and
- Topology-wise – which relates to attacks where access to a view of the entire system and its status is effectively gained by the attacker.

Other types of attacks are[11]:

- **Malware Spreading**: Situation where malware replaces or adds functions to a device or some software in a system,
- **Access via Database Links**: Situation where databases of control systems is mirrored to a business network, and if the database systems are not properly configured, an attacker could gain access to the business network and exploit control system network,
- **Comprising communications equipment**: Situation where weaknesses in the communications hardware could be exploited, example may be hacking some multiplexers or using it as a backdoor to enable future attacks,

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[9] Flick T and Morehouse J. Securing the Smart Grid: Next Generation Power Grid Security. Syngress, 2010.

[10] Sources: Wei D, Lu Y, Jafari M, et al. Protecting smart grid automation systems against cyberattacks. IEEE Trans on Smart Grid, 2011; 2(4):782-795, and Wei D, Lu Y, Jafari M, et al. An integrated security system of protecting smart grid against cyber-attacks. In: Proc. of the IEEE PES Conference on Innovative Smart Grid Technologies, 2010:1-7.

[11] Source: Fadi Aloula, A. R. Al-Alia, Rami Al-Dalkya, Mamoun Al-Mardinia, Wassim El-Hajj, "Smart Grid Security: Threats, Vulnerabilities and Solutions", International Journal of Smart Grid and Clean Energy, vol. 1, no. 1, September 2012.

- **Injection of false information**: False data packets sent into a network – such as false prices, false emergency events etc. which can have negative consequences for operation of an electricity market,
- **Network Availability**: Essentially denial of service attacks via IP protocols, which can delay, block, or corrupt information transmission to make smart grid resources unavailable,
- **Eavesdropping and traffic analysis**: monitoring network traffic, intercepting it and acting on it in a malicious manner,
- **Modbus security issue**: Modbus is a core technology in SCADA systems responsible for exchanging information. Modbus was not designed with security in mind, but under smart grid systems SCADA systems are being integrated with systems that expose SCADA systems and make them more vulnerable to Modbus related attacks.

5.3 Measures to Mitigate the Security Risks of Smart Grid[12], [13]

Measures to mitigate the security risks for Smart Grid are clearly important and need to be considered within the Smart Grid Roadmap. The following sets out some general approaches and solutions to mitigate security risks, however, the topic is quite vast, and it would be necessary to periodically conduct assessments to identify vulnerabilities and implement measures to mitigate them.

5.3.1 Network security

Denial of Service (DoS) is the most common form of network security breach. Therefore, measures to mitigate these attacks are critical. Measures include:

- Network Intrusion Prevention System (IPS) technology, and
- Network Intrusion Detection System (IDS) technology.

These augment the host-based defences to protect the system from outside and inside attacks.

Having devices support Virtual Private Network (VPN) architectures for secure communication is also commonly recommended.

5.3.2 Data security / authentication

The identity of data transfers should in general be verified by implementing authentication mechanisms. The protocol must operate in real-time abiding with some constraints such as minimum computational cost, low communication overhead, and robustness to attacks, especially Denial-of-Service attacks.

Cryptography methods and algorithms are used to encrypt data to secure communication, protect user information, and to authenticate users to prevent attacks against data integrity.

In encryption, both Symmetric Key encryption and Public Key encryption are used in Smart Grid networks. Symmetric key requires lower computing capabilities, public key has been proven to be more secure and is easier to implement when it comes to key management.

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[12] Source: Fadi Aloula, A. R. Al-Alia, Rami Al-Dalkya, Mamoun Al-Mardinia, Wassim El-Hajj, “Smart Grid Security: Threats, Vulnerabilities and Solutions”, International Journal of Smart Grid and Clean Energy, vol. 1, no. 1, September 2012.

[13] Source: Salsabeel Shapsough, Fatma Qatan, Raafat Aburukba, Fadi Aloul, A. R. Al Ali, “Smart Grid Cyber Security: Challenges and Solutions”, Department of Computer Science & Engineering American University of Sharjah, UAE, 2015.

However, due to the variation of computational capability of devices across smart grid networks, which range from simple sensors to smart phones and computers, both forms of encryption are used. The choice of which type of encryption to use in a certain part of the network depends on factors such as computation capability, time contains, and data-criticality.

Another approach that enables devices to know the sources and destinations they communicate with can be accomplished through mutual authentication techniques using Transport Layer Security (TLS) or Internet Protocol Security (IPSec).

5.3.3 Malware protection

Malware protection of both embedded and general-purpose systems is important.

For embedded systems, the system should only run software that is supplied by the manufacturer. The manufacturer is required to embed in its products a secure storage that contains keying material for software validation. Using a key, the system can validate any newly downloaded software prior to running.

For general-purpose systems, third party software is often deployed. For such systems, up-to-date and frequently updated antivirus software along with host-based intrusion prevention are necessary measures to mitigate against the possibility of malware.

5.3.4 Key security

Key management plays a significant role in authentication and encryption to achieve a secure system. Two areas of key security are:

- Public Key Infrastructure (PKI), and
- Symmetric Key Management.

PKI technology ensures the security by verifying the identity of the party through receiving a certificate from the certificate authority (CA) before establishing any communication. Devices should be set up to use Public Key Infrastructure (PKI) to secure communications. However, some constraints apply in terms of cryptography and key management – one issue is that current devices often lack processing power and storage to perform advanced encryption and authentication techniques, communications in a smart grid system will be over different channels that have different bandwidths, and connectivity, where all devices, certificate authorities, and servers must be always connected.

Symmetric key management is used in symmetric cryptography which is composed of key generation, key distribution, key storage, and key update. This overcomes some of the issues for PKI - in particular, symmetric key management is faster and more efficient than PKI.

5.3.5 Network security protocols

As noted earlier, many Smart Grid systems use internet-based protocols for secure communication, including IPSec and TLS.

However, Smart Grids have requirements that differ from internet-based data networks, and there are protocols and standards that are more suitable for use.

These include:

- Secure DNP3, and
- IEC 61850 and IEC 62351.

These modifications are Smart Grid communication protocols that have additional security layers added into the architecture. They are used for end-to-end communication in the smart grid such as communication between different sensors.

5.3.6 Compliance checks

Compliance checking is done through automated tools that run checks across all components in the system to ensure that configurations of each component are up to standards of secure mitigation and protection. This can point to weaknesses that need attention or addressing.

5.3.7 Practices that can address risks to security

There are numerous general practices that can help to mitigate the risks to security, including:

- Running security awareness programs for users to educate users about security risks, and best practices for using network tools and applications,
- Undertaking vulnerability assessments on at least a yearly basis to make sure that elements that interface with the perimeter are secure,
- Seek as a general principle to only collect, transfer, and manage the least amount of data that is needed to achieve a given task or objective – the less information made available, the less opportunities for it to be hacked,
- It is important to leverage both control system engineering expertise and IT security engineering expertise to secure Smart Grid network,
- Security needs to be a consideration in the design of Smart Grids. Otherwise, security of devices becomes vendor specific; the fact that might produce many vulnerabilities because of incompatibility issues.
- Specialist third party communication companies should be leveraged regularly to mitigate the security risks.

5.3.8 Cyber Security Policy and Standard

The need for establishing a cyber security policy and procedures is clearly an important and critical activity. It should be noted that there is a need to continuously revise and update such procedures / policies as the industry evolves and as new technologies become plugged into the Smart Grid.

Refer to the Study Report on Smart Grid Technology and International Experience for examples of Cyber Security standards applicable to smart grids.

5.4 Implications for Updated Smart Grid Roadmap

Communications infrastructure to support Smart Grid operations have two main dimensions: communications infrastructure and associated standards and ensuring security of the communications technologies themselves (which have been discussed in section 3.9).

The approach for cyber security within the context of communications technologies in the Updated Smart Grid Roadmap is recommended to be:

- *Short-term focus (to 2030):*
  - Undertake WAN and LAN communication infrastructure is cyber security audit and network performance review,

- Based on the findings make investments to enhance performance and security, in particular network security investments to ensure WAN/LAN security is being addressed, and
- Update / improve cyber security standards for WAN/LAN technologies and associated software platforms that utilise them.

- *Longer-term focus (to 2050):*
  - As it becomes necessary to roll out NAN/FAN and HAN/BAN/IAN networks, PCs will need to undertake network vulnerability assessments, and make investments in communications infrastructure as required to support the evolving localised networks and communications, and
  - Cyber security standards will need to be expanded to cover localised networks and address their vulnerabilities.
- *Supporting Legislation and Institutional Arrangements*:
  - Cyber security standards and procedure need to be established,
  - Communication protocols and standards defined / agreed to for Smart Grid technologies being deployed,
- *Ongoing focus:*
  - Vulnerability assessments should be carried out on an annual basis and can be included as part of the Cyber Security standard / procedures.

6 Updated VietNam Smart Grid Roadmap

6.1 Approach

The previous sections have identified requirements for the Updated Smart Grid Roadmap to include:

- Section 2 sets out Smart Grid Roadmap requirements based on the current situation in Viet Nam in relation to implementation progress against the policy requirements,
- Section 3 provides a summary of the Smart Grid technologies deployed in many international jurisdictions and identifies those of relevance to Viet Nam that need to be considered in the Smart Grid Roadmap,
- Section 4 provides the general findings from international review and experience and identifies lessons / implications for the Smart Grid Roadmap, and
- Section 5 covers Cyber Security in the context of Smart Grids because as an area not explicitly covered in the other reports.

All the requirements have been arranged into actions for the period 2025-30 and actions for beyond 2030, to the Year 2050. And this has subsequently been formulated into a suitable structure of the Updated Smart Grid Roadmap.

6.2 Smart Grid Roadmap Structure

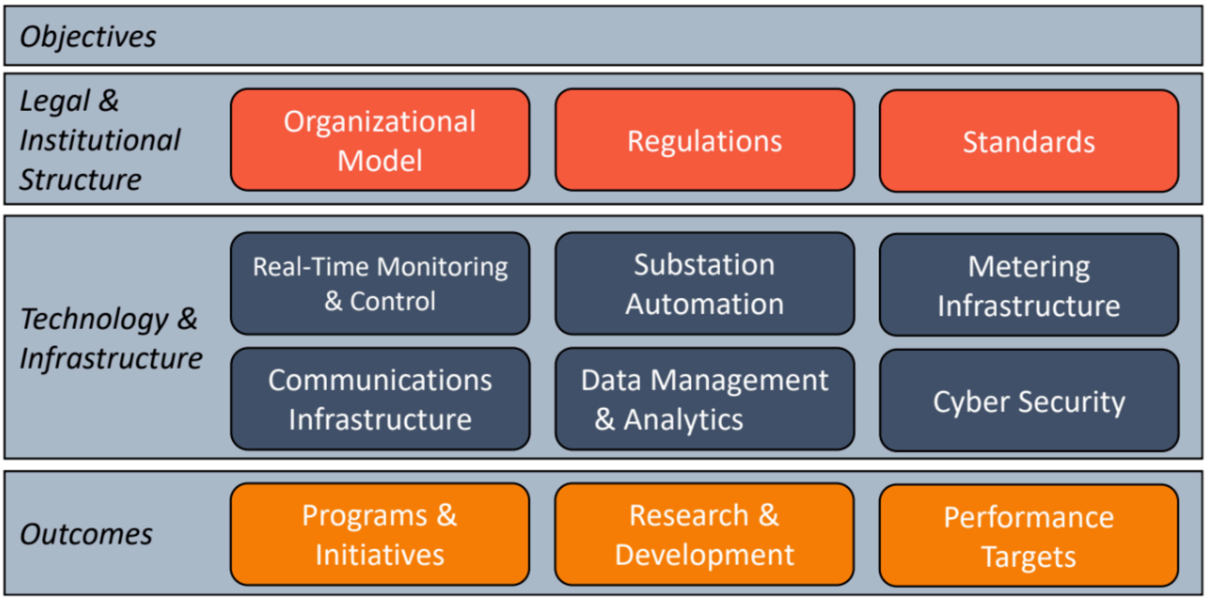
The Updated Smart Grid Roadmap has been structured to be consistent with the original Smart Grid Development Roadmap of Prime Minister Decision No. 1670/QD-TTg (8 November 2012).

The original Smart Grid Roadmap was structured as follows:

- Objectives of the Smart Grid policy,
- List of targets, which are essentially more detailed objectives or key performance indicators (KPIs),
- A list of specific actions to be accomplished across three periods of time / periods, and
- Organizational elements – assigning responsibilities to individual entities within Viet Nam's power sector.

The Updated Smart Grid Roadmap proposed below follows this basic structure and for completeness it is illustrated in Figure 7.

Figure 7. Structure of Smart Grid Roadmap



6.3 General Objectives of Updated Smart Grid Roadmap

6.3.1 Proposed objectives

The general objective is to continue the development of an intelligent power grid with modern technologies that aim to enhance power quality and supply reliability, contribute toward the efficient management of power demand, encouraging efficiency in the use of energy resources, enhance labour productivity, reduce demand of investment in power grid and source development, strengthen reasonable exploitation of energy resources, ensure national energy security, and support energy sector transition towards net zero greenhouse gas emissions by 2050 and contribute towards environmental protection and sustainable socio-economic development.

Other objectives include the modernization of the energy conversion chain from production, transmission, distribution to support the operation of the electricity market, integrate large-scale renewable energy sources, enhance the power system security, and to ensure quality of service is maintained within acceptable limits. Smart Grid Roadmap should also support the implementation of demand side management programs and demand response schemes and minimize electrical losses. It should move the power system in the direction of modernization of control systems, increased automation and increased applications and deployment of intelligent technologies.

6.3.2 Explanation and rationale

The objective remains the same as in the original Smart Grid Roadmap however the alignment with energy sector transition is indicated as part of the longer-term objective – i.e. the Updated Smart Grid Roadmap is intended to support the energy sector transition.

6.4 Legislation and Technical Standards

6.4.1 Objectives

Legislation and technical standards need to support the entry and/or integration of new technologies. The objective of this section is to identify the key policies, incentives, and technical standards that will be required to support the integration of Smart Grid and other technologies in Viet Nam's power system.

6.4.2 Proposed legislation for incentive mechanisms by 2030

The following legislation needs to be established before 2030 by MOIT / ERAV (regulations that create any change to the existing taxation and/or electricity price formulation schemes will need to be endorsed by MOF):

- Incentive mechanism for smart grid applications in new and renewable energy,
- Incentive mechanism for smart grid applications in zero energy buildings,
- Incentive mechanisms for smart grid applications in energy trade between customers and power companies,
- Incentive mechanism for synchronous condensers, and
- Incentive mechanisms for residential customers participation in DSM.

6.4.3 Proposed regulations for technology integration by 2030

The following regulations for technology integration need to be developed by MOIT / ERAV and MOST:

- Regulations for integration of energy storage systems,
- Regulations for smart appliances capable of adjusting the demand based on supply conditions or electricity tariff,
- Distributed Energy Resource (DER) framework,
- Regulations for Virtual Power Plants (VPP) regulatory framework,
- Electric Vehicle and V2G regulatory framework.

6.4.4 Technical standards required by 2030[14]

Standards and technical requirements in the following areas need to be agreed and put into place prior to large scale technology deployment by 2030. It is noted that MOST is responsible for development and issuance of national technical standards for specific equipment and facilities, whereas MOIT / ERAV shall set out technical requirements and regulations for the operation and management of the equipment and facilities in the power system. In addition, sector specific regulations will need to be developed by the corresponding Ministry, for instance, MOC would oversee technical requirements for Building Energy Management Systems.

- Electricity industry-wide cyber security standards,
- Smart inverters,
- Smart meter technical standards,
- Battery Energy Storage Standards,

[14] Refer to the D3 Report for further discussion of technical standards.

- Building Energy Management Systems,
- Centralised solar forecasting standards:
  - Centralised utility-scale solar forecasting system standard,
  - Centralised rooftop solar PV forecasting system standard,
- Centralised wind forecasting standards:
  - Centralised onshore wind forecasting system standard,
  - Centralised offshore wind forecasting system standard,
- Dynamic Line Rating (DLR)
- WAMS / PMUs,
- Distributed Energy Resource Management System (DERMS),
- GIS network and real-time status display for transmission networks,
- GIS network and real-time status display for distribution networks,
- Fault Location, isolation, and service restoration (FLISR) for distribution networks,
- Metering standards enhanced to ensure it covers: AMI, AMR, and centralised Metering Database Management Systems (MDMS) at PCs.

6.4.5 Technical standards required beyond 2030

Standards in the following areas need to be agreed and adopted prior to large scale technology deployment beyond 2030, if it is envisaged that the technology will be rolled out in Viet Nam by MOIT / ERAV and MOST:

- HVDC standard,
- FACTS standard,
- Smart Meter standard,
- Intelligent End-Use Devices, and
- Automated Home Systems.

6.4.6 Explanation and rationale

The purpose of this part of the Smart Grid Roadmap is to identify the required legislation and its sequencing to match the expected changes to Viet Nam's power system as it undergoes energy transition. It is intended to identify the technical standards that are recommended to be established before new smart grid technologies are rolled out.

6.5 Real-Time Monitoring and Control

6.5.1 Objectives

Establishing a reliable real-time monitoring platform for Viet Nam's power system is the core requirement for deployment of more advanced tools and applications that can support the integration of higher levels of renewable energy, encourage efficiency and generally support the energy sector transition. Traditionally real-time monitoring has been focused on the high voltage, / generation and transmission part of the industry, however, the increasing trend towards distributed energy resources (DER) including behind-the-meter rooftop PV and behind-the-meter BESS, is necessitating the need for the market and system operator to have greater real-time visibility of the power system and have coverage of a subset of distribution network assets.

The targets and actions defined in this part of the roadmap are focused on addressing this.

6.5.2 EVN NLDC and RLDCs targets and actions by 2030 – SCADA / EMS

By 2030, complete comprehensive data collection, monitoring, and control system (SCADA) for all power plants and substations at EVN NLDC and the RLDCs:

- Studies / assessments:
  - EVN NLDC and RLDCs undertake detailed assessment into SCADA communications signal stability and reliability to identify solutions and investments to ensure that all key signals from power stations and substations will be 100% stable.
- Investments:
  - Make investments necessary to achieve 100% reliable and stable signal communications for power plants >= 30 MW, 500 kV substations, 220 kV substations and 110 kV substations,
  - Make investments necessary to ensure that the EMS functionality can be fully utilized, and all key functions are exploited.
- SCADA monitoring / EMS functionality targets:
  - **Power plants with capacity greater than 30 MW**: Continue to ensure that 100% of power plants are monitored via the centralised SCADA system and ensure that 100% of SCADA connections provide a stable signal.
  - **500kV substations**: Continue to ensure that 100% of 500kV substations are connected to the SCADA system and that the proportion of 500kV substations having sufficient SCADA is increased to 100%.
  - **220kV substations**: Continue to ensure that 220kV substations have SCADA systems connected, and work towards 100% of them providing stable signals.
  - **110kV substations**: SCADA connections set up for 100 % substations at this voltage level, and 100% having reliable signal quality.
  - All functionalities of the EMS of the SCADA/EMS fully implemented and utilized at NLDC and RLDCs, including:
    - Full real-time nodal security-constrained economic dispatch,
    - Dynamic Line Rating (DLR),
    - Utility-scale solar forecasting system,
    - Rooftop solar forecasting system,
    - Onshore wind forecasting system,
    - Offshore wind forecasting system,
    - WAMS / PMUs for 500 kV,
    - WAMS / PMU for 220 kV,
    - DERMS,
    - OMS for generation and transmission assets,

    - GIS network and real-time status display for transmission networks,

- Continue to ensure that 100% of all RE plants are monitored in real-time and centrally controlled when necessary – for example – curtailment.

6.5.3 EVN NLDC and RLDCs targets and actions by 2040 – SCADA / EMS

By 2040 EVN NLDC and RLDCs should ensure tighter integration between SCADA / EMS functionality and the SCADA/ADMS systems of the PCs. This is to ensure that EVN NLDC and the RLDCs have full centralised visibility of decentralised resources and statuses, including:

- Development of a coordination model for managing distributed resources between EVN NLDC / EVN NPT and EVN NLDC / EVN PCs,
- Enhance communication protocols and the ability to link and exchange information between the NLDC, RLDCs and distribution grid control and monitoring centers,
- Large Distributed Energy Resources (such as generators >= 30 MW),
- Aggregated rooftop PV generation in critical network locations,
- Status of EV charging stations, and
- Localized climate and weather information.

6.5.4 PCs targets and actions by 2030 – SCADA / DMS / ADMS

By 2030, complete comprehensive data collection, monitoring, and control system (SCADA) for all PCs:

- Studies / assessments:
    - Undertake analysis into the feasibility of upgrading or replacing existing SCADA/DMS with SCADA/ADMS to exploit greater functionality offered.
    - Undertake analysis and research into the deployment and feasibility of DERMS software application package for real-time visibility of DERs and VPPs at low voltages.
    - Enhance Solar Rooftop PV monitoring & control by area in terms of output, ability to curtail and forecast.
- Investments:
    - Make investments necessary to achieve 100% stable signal communications for 110 kV substations, 35 kV substations and 22 kV substations,
- SCADA monitoring / DMS / ADMS functionality targets:
    - Continue to ensure that 100% of customers with monthly electricity consumption greater than 1 million kWh have remote monitoring set up and in operation.
    - Continue to ensure that 100% of rooftop solar systems >= 1 MW are monitored in real-time.
    - Implementation of DERMS at 50% of distribution dispatch centers,
    - **110kV substations**: SCADA connections set up for 100% substations at this voltage level, and 100% having reliable signal quality.
    - **22 kV / 35 kV intermediate substations (110-22 kV / 110-35 kV)**: Ensure 100% of 22 kV and 35 kV substations are connected to the SCADA system and that the proportion of substations having sufficient SCADA is 100%.

6.5.5 PCs targets and actions by 2040 – SCADA / DMS / ADMS

By 2040 complete significant enhancements to SCADA/DMS/ADMS functions as follows:

- Upgrades of SCADA/DMS to SCADA/ADMS to exploit greater functionality offered, including GIS, OMS, CIS, and including:
  - Fault Location, Isolation and Service Restoration (FLISR) is a software application.
  - Voltage and reactive power monitoring,
  - Distributed Energy Resource Management System (DERMS),
  - GIS network and real-time status display for distribution networks,
  - OMS for distribution network assets,
- Investment in DERMS software application package for real-time visibility of DERs to ensure that rooftop systems >= 1 MW continue to be monitored in real-time plus any aggregations of solar rooftop within a particular locale that may need to be monitored by the PC or (in the case of large aggregations) NLDC,
- Investment in systems to monitor VPPs at low voltages and provide NLDC with the required information for VPPs that are large, and which need to be monitored by NLDC.
- Incorporate Rooftop PV monitoring and control software in SCADA/ADMS.
- Work towards tighter integration between SCADA / EMS of EVN NLDC and SCADA/ADMS of PCs.
- Implementation of DERMS at 100% of distribution dispatch centers.

6.5.6 Explanation and rationale

The purpose of the real-time monitoring area of the Updated Smart Grid Roadmap is to ensure that targets in the areas of SCADA/EMS and SCADA/DMS/ADMS that were not fulfilled from the previous Roadmap will be addressed, and to include additional investments and advancements in Smart Grid technologies that will assist Viet Nam in supporting the energy sector transition.

The other important note is that real-time monitoring should be extended to lower voltages to increase real-time visibility of the system for NLDC's dispatch and system operation role. An important component of this is dynamic monitoring of solar rooftop systems and in the future VPPs, and the status and consumption of EV charging stations.

6.6 Substation Automation

6.6.1 Objectives

The overriding objective of substation automation and remote-control devices is to reduce to 3-5 persons on the duty per 110 kV substation and transition switching operations for medium-voltage equipment to be done remotely.

It is noted that presently there must be at least 1 person attending at any fully automated substation to satisfy the fire safety / prevention requirements.

6.6.2 EVN NPT targets and actions by 2030 and 2040

The following requirements apply to EVN NPT by 2030:

- For 220 kV substations: EVNNPT works towards automation of all 220kV substations in accordance with the unstaffed automated criteria, noting fire safety regulations.
- For 500 kV substations: continue to ensure full automation of 500 kV substations.

Beyond 2040, ensure that all 220 kV and above substations continue to be fully automated and invested in line with best industry practice.

6.6.3 PCs targets and actions by 2030 – Substation Automation

The following requirements apply to EVN PCs by 2030 in relation to substation automation:

- For 110kV substations: the Power Corporations have successfully put 100% of the RCCs into operation and achieved a 100% rate of 110kV substations operating in compliance with the fully automated criteria.
- Target for 50% medium-voltage substations to be remotely monitored and operated.
- Studies / assessments:
  - Undertake analysis into the feasibility of fully automating all medium voltage substations at 22kV, 35kV and any substations < 110 kV.

6.6.4 PCs targets and actions by 2040 – Substation Automation

The following requirements apply to EVN PCs by 2040 in relation to substation automation:

- Ensure 100% automation of 22kV, 35kV and any substations < 110 kV by making necessary investments.

6.6.5 Explanation and rationale

Substation automation is driven not only by the savings in having lower staffing numbers at substations but to also provide greater flexibility in the operations of the power system at lower voltages which becomes more critical with increasing distributed generation resources.

6.7 Metering Infrastructure

6.7.1 Approach

Modernization of metering infrastructure is an important step towards automation and generally forms an important precondition for roll out of Smart Grid technologies and platforms such as Demand Response, VPPs, smart end-use appliances, improved consumer engagement / participation in electricity markets, Distributed Energy Resources, and participation of prosumers in general. While Viet Nam has made some progress on this under the previous Smart Grid Roadmaps, as such the Updated Smart Grid Roadmap has put in place a step-by-step strategy to improve the metering arrangements over time, with the responsibility assigned to NPT and PCs.

6.7.2 NPT targets and actions

NPT is to continue to ensure the conditions that:

- 100% of substations at 110 kV, 220 kV and 500 kV are 100% fitted with electronic meters with remote measurement capability, and
- 100% of large customers of NPT are fully metered with electronic meters that have remote measurement capability.

6.7.3 PCs targets and actions

Deployment of electronic meters with remote measurement capabilities across Viet Nam's power system:

- By 2030, 95% of all PC customers to be fitted with electronic meters that at least have remote measurement capability – with priority given to large customer, industrial customers, and commercial customers,
- By 2040, 100% of all PC customers will be fitted with electronic meters that at least have remote measurement capability.

6.7.4 AMI capability

- By 2030, NPT and all PCs are to have completed an AMI pilot with customer meters.
- By 2035, NPT and all PCs are to have AMI capability in place, if not already.

6.7.5 Smart meters

By 2030, once technical standards for Smart Meters are in place each PC is to conduct a 1-year trial with at least 1000 customers on Smart Meters and report on the lessons and benefits of their roll out,

By 2035, or once either of the following conditions are satisfied:

- Customers can be exposed to dynamic pricing – including wholesale market customers or those exposed to retail market prices, or
- DR incentive mechanism in place.

PCs are to make smart meters available to their customers and support their functions and operation.

6.7.6 Explanation and rationale

Modernized metering infrastructure is a foundation for the integration of more advanced smart grid technologies. The general direction and purpose of the Updated Smart Grid Roadmap is to firstly satisfy the original targets from 2012 and 2016 in respect to metering infrastructure and to set a vision for the implementation of AMI and Smart Meters. In relation to Smart Meters, the main benefit of implementation is dynamic pricing and/or an incentive mechanism for responsive load. As these are not fully in place in Viet Nam, the rollout of smart meters has been made contingent on these policy developments.

6.8 Programs and Initiatives

6.8.1 Commercial DR programs

By 2030:

- PCs to undertake additional commercial DR pilot programs, seeking to advance beyond previously implemented commercial DR pilot programs.

Beyond 2030:

- Based on the results of Pilot DR programs, if feasible and viable, implement.

6.8.2 Integration of distributed energy resources (DER) – by 2030

- Develop the Distributed Energy Resources (DER) Management System at the NLDC, RLDCs and Distribution Companies.
- Development of a TSO/DSO coordination model for managing distributed resources.
- Gradually integrate energy storage systems to optimize mobilization and operation of distributed sources. Experiment small-scale energy storage modules to balance supply and demand at the end-user level.
- Investigate the potential for implementing microgrids in important load locations, remote areas, and islands; microgrid systems that integrate battery storage systems and smart electric vehicle charging stations.
- Examine new operational management models for amalgamation of many distributed energy resources, such as virtual power plants.

6.8.3 Integration of EV charging stations

Explore tools and solutions for managing electric vehicle charging stations and their integration into the demand management systems of the power companies to help achieve the overall effectiveness of the electrical system.

6.9 Data Management and Analytics

By 2030:

- Geographic Information System (GIS): Set a target of 50% transmission and distribution network management units by 2030 to develop and implement GIS for power grid management. GIS should be able to map all the electrical assets with indexes on all customers. This enables the electricity utility to plan and manage its operations accordingly.
- PCs to have 95% of consumer requests to be handled by online / digital platforms.
- Key applications and databases transitioned into cloud-based data servers.

Beyond 2030:

- PCs to have 98% of consumer requests to be handled by online / digital platforms by 2045.
- Advanced Analytics (AA) and Artificial Intelligence (AI): Gradually apply artificial intelligence and data analytics in monitoring, energy consumption and demand forecasts, equipment condition assessment and system fault forecasting. Technologies equipped with sensors and smart equipment capture operational data in digital format. Data collected can be used to provide insights into asset performance and customer electricity consumption resulting in efficient network planning and capital expenditure for utilities.
- Cloud computing and containerisation: Utilities are increasingly moving towards the use of cloud computing. Cloud computing is the practice of using a network of remote servers hosted on the internet to store, manage, and process data, as opposed to using a local server or a personal computer. It provides access to shared computer processing power via the internet and is usually high performance. Examples include Azure Blob Storage, Docker (open-source container-based solution), Kubemetes / AKS, Key Vault (Azure), SQL Server, Cosmos DB, Apache Kafka, and Cucumber / Specflow (BDD / Automated testing).

6.10 Communications Infrastructure

By 2030, ensure that 100% of rural district power companies have fibre-optic connections in place so that they will be connected to a dedicated EVN system.

6.11 Cyber Security

6.11.1 Objectives

Cyber security within the context of smart grids is concerned with taking measures across all organisations within the electricity industry to ensure: (1) confidential data is protected, (2) ensuring the integrity of data and information, (3) putting in place measures to ensure authentication and only authorised access is provided to data, (4) auditing and monitoring to ensure continuous improvement, (5) having measures in place for handling breaches in cyber security – incident response, (6) ensuring staff are aware of security risks at all times, and (7) complying with other standards and regulations.

Key organisations that are critical to ensuring cyber security include those that manage significant amounts of data and control / operate the power system: EVN NLDC, EVN NPT, and EVN PCs.

6.11.2 Measures to year 2030

- Undertake WAN and LAN communication infrastructure is cyber security audit and network performance review,
- Based on the findings make investments to enhance performance and security, in particular network security investments to ensure WAN/LAN security is being addressed, and
- Update / improve cyber security standards for WAN/LAN technologies and associated software platforms that utilise them.

6.11.3 Measures beyond year 2030

- As it becomes necessary to roll out NAN/FAN and HAN/BAN/IAN networks, PCs will need to undertake network vulnerability assessments, and make investments in communications infrastructure as required to support the evolving localised networks and communications, and
- Cyber security standards will need to be expanded to cover localised networks and address their vulnerabilities.

6.11.4 Ongoing focus

Vulnerability assessments should be carried out on an annual basis and can be included as part of the Cyber Security standard / procedures.

6.11.5 Explanation and rationale

The data intensive nature of smart grid necessitates cyber security measures and actions being taken.

6.12 Power System Performance Targets

6.12.1 System reliability target

Continue to ensure that reliability of electricity supply in the power system improves and trends towards international benchmarks:

- Supply Average Interruption Frequency Index (SAIFI) does not exceed 0.5[15] per year from 2030, and 0.3 per year from 2040.
- System Average Interruption Duration Index (SAIDI) does not exceed 1.5 hours per year from 2030 and does not exceed 1 hour from 2040.

6.12.2 Technical and commercial electrical losses

Continue to ensure that the technical and commercial electrical energy losses do no exceed 6% and are reduced on a year-on-year basis[16].

6.12.3 VRE curtailment minimisation

- By 2030, ensure VRE curtailment is less than 5% of total generation,
- By 2040, ensure that VRE curtailment is less than 3% of total generation, and
- By 2050 less than 1%.

6.12.4 Explanation and rationale

While Viet Nam has managed to achieve (and exceed) the reliability and electrical loss targets of the original Smart Grid roadmap, it is important to ensure that actions are taken to continuously trend towards international benchmarks.

Accordingly, the SAIDI, SAIFI and electrical loss targets are replaced by international benchmarks.

The VRE curtailment minimization requirement is to create a driver for investments and actions to be taken to limit solar and wind curtailment.

6.13 Research and Development

Promote research and domestic production of intelligent electronic products for the technological needs of smart grids; to allow customers to proactively access and manage detailed information about their electricity usage and costs.

Areas of research that are to be addressed include:

- **Modernization, Monitoring and Control**: Undertake research to enhance the monitoring and control of Vietnam's power system:
  - A comprehensive voltage control system infrastructure for Vietnam's power system,
  - Enhancement to monitoring and management of system inertia automatically and monitoring system strength, automatic voltage regulation, automatic capacity regulation, wide-area monitoring systems to meet the increasingly for operating the power with a very large level of renewable energy sources.

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[15] The average number of service interruptions experienced by a customer in a year.

[16] It is noted in the "Study report on the status of smart grid development in Viet Nam", that the electrical losses reached 6.42% which was significantly lower than the original Smart Grid's target of 9%.

- **Enhancing Customer Experience and Engagement**: Undertake research into improving customer experience and engagement, including the following:
  - Develop the criteria, methods, and procedures for evaluating service quality, empowering customers, and ensuring customer satisfaction, ensuring transparency and openness in customer service,
  - Implementation of customer service applications, especially applications on digital platforms, public services, cashless payment, customer care, and resolving customer requests on digital platforms.
  - Measures to better utilize the data from customer databases, conduct studies on market analysis, customer's habits, behaviours, and needs to improve service quality and enhance customer satisfaction.
- **Virtual Power Plants (VPPs)**: Research on the models and regulations to support the operation of VPPs, as informed by international experience:
  - Technologies and deployment modes of VPPs,
  - Regulations and standards to govern the operation of VPPs, and
  - Business models and incentive mechanisms for VPPs.
- **Enhancing Power System Stability**: Improving the modes and mechanisms for identification of stability issues to inform ways of operating the power system within a secure envelope:
  - Power system stability, optimization and control,
  - Mechanisms and approaches for power system monitoring, operations and control,
  - Simulating and assessing stability of power systems with Inverter Based Resources.
- **System Strength Monitoring[17] and Methods to Alleviate**:
  - Establishing procedures and practices to systematically monitor for system strength issues in the power system,
  - Identification of measures and actions that can avoid occurrence of system strength related problems, and
  - Development of regulations and incentives to avoid system strength issues in the power system.
- **Microgrids**: Investigation into the role and benefits of microgrids in power systems
  - Methodologies for modelling and analysing microgrids,
  - Microgrid technologies and interfaces to support their operation, and
  - Evaluation of grid impacts of microgrids and control techniques to ensure
- **Machine Learning (ML) and Artificial Intelligence (AI)**:

[17] System strength – defined by AEMO – is: "the ability of the power system to maintain and control the voltage waveform at any given location in the power system, both during steady state operation and following a disturbance. The system strength at a given location is proportional to the fault level at that location, inversely proportional to effective grid-following IBR penetration seen at that location.", *Source*: System Strength Explained (aemo.com.au)

  - Assessment of potential applications and uses for ML and AI in relation to enhancing the operation and optimization of power systems, and identification of patterns and trends in operations, and
  - Review of ML and AI technologies and approaches to their deployment.
- **Community Batteries and Distributed Energy Storage**:
  - Undertake an assessment of the options, roles and feasibility of deploying small-scale energy storage systems at distribution substations to enhance distribution network asset utilization and management,
  - Undertake research on grid impacts of wide scale deployment of distributed energy storage systems on end-user consumers. and
  - Assessment of the hosting capacity for rooftop solar and improvement in distribution substation and network control and reliability improvement.
- **Community Batteries and Distributed Energy Storage**:
  - Undertake an assessment of the options, roles and feasibility of deploying small-scale energy storage systems at distribution substations to enhance distribution network asset utilization and management,
  - Undertake research on grid impacts of wide scale deployment of distributed energy storage systems on end-user consumers. and
  - Assessment of the hosting capacity for rooftop solar and improvement in distribution substation and network control and reliability improvement.
- **Electric Vehicle infrastructure and Grid Integration**:
  - Grid-to-vehicle and Vehicle-to-grid,
  - Electric Vehicles Integration,
  - Smart Electric Vehicle Charging Infrastructure,
  - Pricing Models for Charging Stations,
  - Integration of Electric Vehicles and Battery Technology,
  - Vehicles-to-grid communications protocols and mechanisms,
  - Modeling and simulation tools and methods for interaction of grids, charging stations and EVs.
- **Smart Cities:**
  - Home energy management systems,
  - Internet of Things,
  - Sensing, monitoring and control of end-use devices,
  - Transport infrastructure, and
  - Communication infrastructure
- **Smart Grid Networking and Communications Technologies**:
  - Broadband wireless communication networks,
  - Communications and Networks for Smart Grids and Smart Metering,

- Wide-area Visualization for Enhanced Situational Awareness (PMUs, Micro-PMUs, and Other Visibility and Control Devices and Applications),
- Enabling Information and Communication Technologies,
- Communication cyber security standards and technologies,
- Cyber Attack Impact on Critical Smart Grid Infrastructures
- Smart Grid Sensor Technology
- Wireless Communications and Networks for the Smart Grid Last Mile
- Grid Edge Enabling Technologies
- Broadband Wireless and Smart Grid
- Sensors Use for Energy Management
- Communication and Cyber Security

It is recognized that as the industry evolves the research needs and challenges will continue to change. As such the above is a general list of areas and technologies that are either less widely adopted in power systems, but which could offer significant benefits or areas that are commonly adopted in some power systems but yet to be deployed in VietNam.

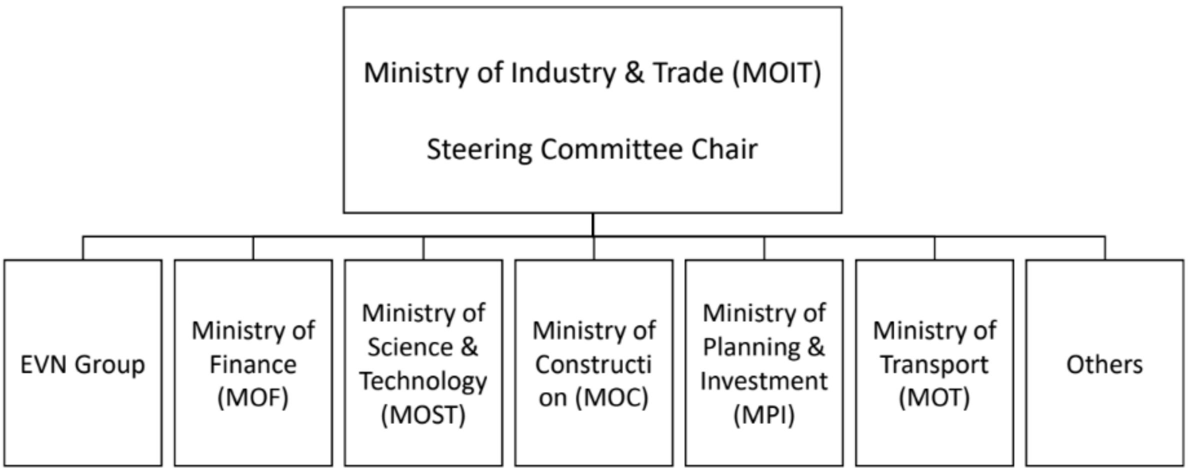
6.14 Organisational Implementation

6.14.1 Steering Committee

To ensure effective implementation of the Smart Grid Roadmap a Steering committee is to be chaired and convened by MOIT. The Steering Committee will have representation from relevant stakeholders and be focused on monitoring the implementation of the smart grid, and addressing and resolving implementation challenges as they arrive.

An illustration of the Steering Committee is shown in Figure 8. The roles and responsibilities of each ministry are set out in the sections that follow.

Figure 8. Steering Committee



6.14.2 Role of MOIT

MOIT's role is as follows:

- Establish a Smart Grid Steering Committee (Technical Working Group):

- The head is a leader of the MOIT, the standing agency is ERAV.
- Has representatives of the following ministries: Finance, Planning and Investment, Science and Technology, Construction, EVN, and other relevant agencies / units.
- The Steering Committee has the duty of directing different units in the electricity sector to formulate specific projects and define specific targets in each project, assigning project implementation tasks to the relevant units and supervising their implementation.
- It is proposed that the Steering Committee convene regularly with frequency not less than once per month.

- Oversee and monitor the implementation of Smart Grid Roadmap in Viet Nam in accordance with the approved Smart Grid Roadmap. As part of this role MOIT should report on the status of Smart Grid implementation to the regularly convened meetings with input from EVN Group.
- Promulgate or submit to the Prime Minister for promulgation: legal documents, technical standards, necessary mechanisms, and policies under their authority to promote the development of Smart Grid technologies in Viet Nam.
- Be responsible for, and coordinate with the Ministry of Finance to formulate suitable financial mechanisms to mobilize capital sources for investment in infrastructure of smart power grids under each region and specific period, aiming at effectively using the capital sources and sharing the costs and benefits with clients.
- Be responsible for, and coordinate with the Ministry of Construction and relevant Ministries, agencies to formulate incentive mechanisms for application of smart power grids in Zero Energy Buildings / Houses and Smart Cities.
- Be responsible for, and coordinate with the Ministry of Planning and Investment and relevant Ministries, agencies to find financing capital sources of countries and international organizations for technical assistance projects to complete the legal framework for smart grids development, develop technical standards, formulate specific Smart Grid programs and implement pilot projects in Viet Nam.
- Be responsible for, and coordinate with relevant units to implement approved Smart Grid pilot projects.

6.14.3 Role of EVN Group

- Formulate detailed plans to implement the Smart Grid Roadmap initiatives, form task groups for each period, submit to the Ministry of Industry and Trade to approve specific targets for each program, project, task groups.
- Implement Smart Grid projects in Viet Nam in conformity with the approved Roadmap's timeline.
- Train the staff and enhance their capability for management and operation of Smart Grid technologies and systems in the future.
- Invest in the necessary infrastructure to develop Smart Grid and rollout Smart Grid technologies in accordance with the approved Roadmap.

6.14.4 Role of Ministry of Finance (MOF)

Advise on matters related to funding Smart Grid programmes and pilots and the implementation of measures that created targeted incentives for deployment of Smart Grid in the industry.

MOIT with input from EVN Group are required to advise MOF on costs and benefits of Smart Grid projects ahead of their implementation for approval.

MOIT with input from EVN Group will be required to advise MOF on any financial mechanisms or investment mechanisms that promote the deployment of smart grid applications in Viet Nam's power sector under the Roadmap.

6.14.5 Role of Ministry of Science and Technology (MOST)

Responsible for overseeing research areas of the Roadmap and reporting to the steering committee on the results of monitoring and overseeing research and development on Smart Grid technologies and new applications of the technologies in the power sector.

Support and provide input on the adoption of technical standards to support roll out of new technologies in Smart Grid.

Coordinate efforts for solar and wind forecasting with meteorological measurements and weather forecasting systems.

Where new technologies have been piloted, review the outcomes, and assess the effectiveness of newly deployed technologies. Provide input to MOIT ahead of wider rollout of new technologies.

Report to the Steering Committee on the above listed activities and other tasks within MOST's domain by the Steering Committee to ensure that Smart Grid roll-out and development is effective and achieving the desired targets.

6.14.6 Role of Ministry of Construction (MOC)

Advise the Steering Committee on implementation of zero energy buildings, smart homes and smart cities, where relevant as part of the Smart Grid Roadmap's implementation.

Advise the Steering Committee on the implications for construction codes of conduct and standards, and where relevant proposed and assist in the implementation of changes to codes where they are impacted, or otherwise oversee the implementation of new regulations where they are required.

In coordination with MOT, assess the impact of EV infrastructure and the need for new standards and technical codes.

6.14.7 Role of Ministry of Planning and Investment (MPI)

Advise the Steering Committee on matters related to financing sources for Smart Grid programs and raising of capital to fund Smart Grid pilot projects and/or research into the deployment and application of new technologies.

6.14.8 Role of Ministry of Transport (MOT)

Advise the Steering Committee on implementation of transport infrastructure and roll and trends in relation to electric vehicles as required under the Smart Grid Roadmap's implementation.

Advise the Steering Committee on the implications for transport standards, and where relevant proposed and assist in the implementation of changes to codes where they are impacted, or otherwise oversee the implementation of new regulations where they are required.

In coordination with MOC, assess the impact of EV infrastructure and the need for new standards and technical codes.

6.14.9 Other relevant ministries

Other relevant ministries and agencies are to proactively coordinate with the MOIT under functions, tasks within their state management mandates regarding implementation of the approved Smart Grid Roadmap.

The need for additional ministries or agencies to be seconded to the Steering Committee will be identified during the Steering Committee's ongoing meetings and monitoring of the Smart Grid implementation.

6.14.10 Comparison to original Roadmap organisational model

The organisational implementation model of the original Smart Grid Roadmap continues to be relevant and has largely been adopted with some minor adjustments to be aligned with the updated smart grid roadmap.

7 Guidance on Roadmap Implementation

1.1 Purpose

The purpose of this section is to provide guidance on the implementation strategy for the Smart Grid Roadmap described in section 6. In doing so high priority elements of the Roadmap have been identified. To maximize interoperability and set the platform to support the deployment of real-time monitoring tools that enhance visibility of the grid and identify and avoid threats that would otherwise compromise power system reliability, the period to 2030 puts a high priority on: (1) establishing technical standards and regulations for smart-grid technologies, (2) completion of prior initiatives to improve real-time monitoring and control of the power system, (3) enhancing cyber security, and (4) ensuring the automation of substations and meter data collection. This lays the platform for integrating energy storage technologies, scaling up wind and solar, and supporting the deployment of electric vehicles. Secondary priorities of the Smart Grid Roadmap relate more to technologies that are expected to be deployed in Viet Nam in the period beyond 2030 and to technologies that support prosumers and greater engagement of consumers in the power sector that can be timed with policies to have more active retail markets and dynamic pricing. These considerations have been reflected in the implementation guidelines presented in this section.

1.2 Steering Committee

The Steering Committee needs to be formed with representation from the ministries and agencies described in section 6.14. A critical activity for the Steering Committee will be ensuring that the required policy and standards framework is implemented in a timely manner to support the roll out of new technologies, and subsequently evaluating whether policies and standards are working in the way that was intended or whether they need some adjustments based on actual experience.

1.3 Policy and Standards Implementation Strategy

1.3.1 Period to 2030

During the period to 2030 the following is needed:

Type of Regulation	First Priorities	Secondary Priorities
Incentive mechanisms	• Smart Grid applications supporting RE • Zero energy buildings • Synchronous condensers	• Energy trading mechanism between consumers and power companies • Residential customers participating in DSM
Technology regulations	• Energy storage systems • DER framework	• Smart appliances • VPPs • V2G
Technical Standards	• Industry-wide cyber security standards • Smart inverters • Smart meter technical standards • Energy Storage (BESS and Pumped Storage) • Building Energy Management Systems	• FLISR • Metering standards enhanced to address AMI, AMR and MDMS at PCs

Type of Regulation	First Priorities	Secondary Priorities
	• Solar & wind forecasting standard • DLR • WAMS/PMUs • DERMS • GIS	

1.3.2 Period beyond 2030

Beyond 2030, the following technical standards are proposed to be developed:

- HVDC standard,
- FACTS standard,
- Smart Meter standard,
- Intelligent End-Use Devices, and
- Automated Home Systems.

1.4 Real-Time Monitoring and Control

1.4.1 Period to 2030

During the period to 2030 the following is needed. As real-time monitoring and control is so core to the development of other components of the smart grid, it is a very high priority activity.

Organisation(s)	First Priorities	Secondary Priorities
NLDC and RLDCs SCADA / EMS	• SCADA/EMS Upgrades to ensure 100% reliable and stable communications for all power stations >= 30 MW and substations >= 110 kV • 100% visibility of 500 kV, 220 kV and 110 kV substations and power stations >= 30 MW • Modernize functionality of EMS applications – see section 6.5.2	None
PCs SCADA / DMS / ADMS	• Ensure 100% stable signal communications for 110 kV substations, 35 kV substations and 22 kV substations • 100% of large customers are monitored in real-time. • DERMS implementation for at least 50% of distribution control centers	• DERMS implementation at other distribution control centers

1.4.2 Period beyond 2030

During the period beyond 2030 the following is needed:

Organisation(s)	First Priorities	Secondary Priorities
NLDC and RLDCs SCADA / EMS	• Real-time monitoring of solar rooftop zones • Charging status of EV chargers • Real-time monitoring of all distributed energy resources	• Increased weather station observations and real-time information • Increased interconnectivity with meteorology forecasts
PCs SCADA / DMS / ADMS	• 100% DERMS implementation at distribution control centers • Upgrade functionality of all DMS / AMS to achieve functionality specified in section 6.5.5. • DER visibility • Solar rooftop monitoring & control systems in place • 100% of distribution control centers fitted with DERMS	• Systems to support and monitor VPPs • SCADA / EMS (NLDC / RLDCs) and SCADA/ADMS (PCs) integration

1.5 Substation Automation

1.5.1 Period to 2030

During the period to 2030 the following is needed:

Organisation	First Priorities	Secondary Priorities
EVN NPT	• Ensure 100% automation of all 220 kV substations • Continue to ensure that all 500 kV substations are fully automated	None
PCs	• 110 kV substations: 100% automation • Achieve >= 50% of remote monitoring and operation of medium-voltage substations	• Study into the requirements to fully automated all MV substations at 22 kV, 35 kV and any < 110 kV

1.5.2 Period beyond 2030

Beyond 2030:

Organisation	First Priorities	Secondary Priorities
EVN NPT	• Continue to ensure that all substations >= 220 kV are fully automated	None
PCs	• Take necessary actions to fully automate substations at 22 kV, 35 kV and any others up to 110 kV.	None

1.6 Metering Infrastructure

1.6.1 Period to 2030

During the period to 2030 the following is needed:

Organisation	First Priorities	Secondary Priorities
EVN NPT	• Continue to ensure 100% of 500 kV and 220 kV substations are fully metered with meters that have remote reading capability • Continue to ensure that 100% of large customers are metered with meters that have remote reading capability • AMI Pilot completed	AMI implementation plan developed based on results of AMI pilot.
PCs	• 95% of all PC customers to be fitted with electronic meters that at least have remote measurement capability – with priority given to large customer, industrial customers, and commercial customers, • AMI Pilot completed	AMI implementation plan developed based on results of AMI pilot.

1.6.2 Period beyond 2030

Beyond 2030:

Organisation	First Priorities	Secondary Priorities
EVN NPT	• Have AMI in place	Make smart meters available to customers that want to use them to participate in dynamic pricing or DSM/DR mechanisms.
PCs	• Have AMI in place • 100% of all PC customers to be fitted with electronic meters that at least have remote measurement capability.	Make smart meters available to customers that want to use them to participate in dynamic pricing or DSM/DR mechanisms.

1.7 ICT Infrastructure & Cyber Security: Data Analytics & Communications

1.7.1 Period to 2030

During the period to 2030 the following is needed:

Organisation	First Priorities	Secondary Priorities
NLDC and RLDCs EVN NPT	• 50% transmission and distribution network management units by 2030 to develop and implement GIS for power grid management	• Research conducted into application and use of AI to enhance operations. • Develop strategy to transition key applications into cloud

Organisation	First Priorities	Secondary Priorities
	• Transition key data into cloud-based servers • Undertake a cyber security audit with focus on WAN and LAN communications infrastructure and implement the recommendations. • Develop internal cyber security policies and standards for WAN / LAN and other communications.	• Investigate cyber security standards for HAN, NAN, and other localised networks – where relevant.
PCs	• 50% transmission and distribution network management units by 2030 to develop and implement GIS for power grid management • 95% of consumer requests to be handled by online / digital platforms. • Transition key data into cloud-based servers. • Undertake a cyber security audit with focus on WAN and LAN communications infrastructure and implement the recommendations.	• Research conducted into application and use of AI to enhance operations. • Develop strategy to transition key applications into the cloud. • Investigate cyber security standards for HAN, NAN, and other localised networks – where relevant.
PCs (Rural District Power Companies)	• Ensure that 100% of rural district power companies have fibre-optic connections in place so that they will be connected to a dedicated EVN system.	None.

1.7.2 Period beyond 2030

Beyond 2030:

Organisation	First Priorities	Secondary Priorities
NLDC and RLDCs EVN NPT	• 100% transmission and distribution network management units by 2030 to develop and implement GIS for power grid management • Transition applications and core software into cloud-based solutions • Implementation of Advanced Analytics (AA) more widely across organisations. • Implement cyber security standards for HAN, NAN, and other localised networks – where relevant.	Transition towards greater use of cloud computing and containerisation.

Organisation	First Priorities	Secondary Priorities
PCs	• 100% transmission and distribution network management units by 2030 to develop and implement GIS for power grid management. • 98% of consumer requests are handled by online / digital platforms. • Transition applications and core software into cloud-based solutions. • Implementation of Advanced Analytics (AA) more widely across organisations. • Implement cyber security standards for HAN, NAN, and other localised networks – where relevant.	Transition towards greater use of cloud computing and containerisation.

1.8 Training and Capacity Building

Successful implementation of the Updated Smart Grid Roadmap will require an ongoing focus on training staff at ERAV and EVN entities that would have direct involvement with the technologies involved. A training programme to provide coverage of the high priority standards, technologies and methodology is recommended to be developed and delivered as the implementation progresses.

1.9 Conclusion

The implementation guidelines in this section have provided an overview of the main activities that need to be completed leading up to the year 2030 and highlighted those that are the most critical to implement. These are the investments and actions that are the most important for supporting a scale up in renewable energy, deployment of energy storage technologies and a responsive demand-side. It is strongly recommended that the implementation plan be continuously monitored and updated over time using the experience gained to improve implementation.

2 CONCLUSIONS

1.1 Recommended approach to Updated Smart Grid Roadmap

To address objectives of this report in preparing an Updated Smart Grid Development Roadmap for Viet Nam for the period up to 2030, with a vision for 2050 the results of the following deliverables were leveraged:

- Study report on the status of smart grid development in Viet Nam, and
- Study on international experience.

To determine the requirements for the Updated Smart Grid Roadmap to address in the following way:

- Requirements from implementation of Smart Grid to date in Viet Nam,
- Requirements based on a review of technologies,
- Requirements based on international case studies and lessons, and
- Requirements for cyber security within the context of Smart Grid.

Based on the requirements and on the original Smart Grid Roadmap of 2012, an Updated Smart Grid Roadmap to the year 2030, with a vision to the year 2050, was formulated.

1.2 Updated Smart Grid Roadmap

The Updated Smart Grid Roadmap has been structured to be consistent with the original Smart Grid Development Roadmap of Prime Minister Decision No. 1670/QD-TTg (8 November 2012), with a focus on actions and targets to the year 2030, and actions and targets to be achieved by 2050.

Objectives: The Updated Smart Grid objective is to continue the development of an Smart Grid with modern technologies that aim to enhance power quality and supply reliability, contribute toward the efficient management of power demand, encouraging efficiency in the use of energy resources, enhance labour productivity, reduce demand of investment in power grid and source development, strengthen reasonable exploitation of energy resources, ensure national energy security, and support energy sector transition towards net zero greenhouse gas emissions by 2050 and contribute towards environmental protection and sustainable socio-economic development.

Legislation and Technical Standards: Legislation and technical standards need to support the entry and/or integration of new technologies. The Updated Smart Grid Roadmap assigns the responsibilities for the regulations to relevant ministerial bodies which are to be implemented concurrently with the rollout and integration of Smart Grid technologies in Viet Nam. The Steering Committee is tasked with overseeing the development of regulations. Legislation and technical standards are to be developed in the areas of: (1) incentive mechanisms to encourage smart grid technologies and investment, (2) regulations to integrate new technologies into the power system, and (3) technical standards to ensure the equipment performance is satisfactory and to maximise opportunities for interoperation between different technologies.

Real-Time Monitoring and Control: Establishing a reliable real-time monitoring platform for Viet Nam's power system is the core requirement for deployment of more advanced tools and applications that can support the integration of higher levels of renewable energy, encourage efficiency and generally support the energy sector transition. Traditionally real-time monitoring has been focused on the high voltage, / generation and transmission part of the industry, however, the increasing trend towards distributed energy resources (DER) including behind-the-meter rooftop PV and behind-the-meter BESS, is necessitating the need for the market and system operator to have greater real-time visibility of the power system and have coverage of a subset of distribution network assets.

Substation automation: The overriding objective of substation automation and remote-control devices is to reduce to 3-5 persons on the duty per 110 kV substation and transition switching operations for medium-voltage equipment to be done remotely. It is noted that presently there must be at least 1 person attending at any fully automated substation to satisfy the fire safety / prevention requirements.

Modernization of Metering Infrastructure: Modernization of metering infrastructure is an important step towards automation and generally forms an important precondition for roll out of Smart Grid technologies and platforms such as Demand Response, VPPs, smart end-use appliances, improved consumer engagement / participation in electricity markets, Distributed Energy Resources, and participation of prosumers in general. While Viet Nam has made some progress on this under the previous Smart Grid Roadmaps, as such the Updated Smart Grid Roadmap makes a step-by-step strategy to improve the metering arrangements over time, with the responsibility assigned to NPT and PCs.

Promotion of programs and special initiatives: To promote and create incentives in the industry to advance smart grid technologies in Viet Nam, several important programs have been identified to be important. Those recommended to be implemented by 2030 include: (1) Commercial DR programs, (2) Distributed Energy Resource integration, and (3) Systems to support the integration of Electric Vehicles charging stations in the grid.

Data Management and Analytics: Deploy Graphic Information System (GIS) tools and real-time monitoring facilities or transmission and distribution networks, roll out Advanced Analytics (AA) and Artificial Intelligence (AI) driven applications to enhance monitoring, energy consumption. And demand forecasting equipment condition assessment and system fault forecasting, and transition towards greater use of cloud-based computing and containerisation solutions for analytics and data management.

Communications Infrastructure: By 2030, ensure that 100% of rural district power companies have fibre-optic connections in place so that they will be connected to a dedicated EVN system.

Cyber Security: Cyber security within the context of smart grids is concerned with taking measures across all organisations within the electricity industry to ensure: (1) confidential data is protected, (2) ensuring the integrity of data and information, (3) putting in place measures to ensure authentication and only authorised access is provided to data, (4) auditing and monitoring to ensure continuous improvement, (5) having measures in place for handling breaches in cyber security – incident response, (6) ensuring staff are aware of security risks at all times, and (7) complying with other standards and regulations.

Power System Performance Measures: As with the original Smart Grid Roadmap, several performance measures have been introduced into the Updated Smart Grid Roadmap, requiring Vietnam to trend towards international best practices for: (1) system reliability, (2) electrical losses, and (3) threshold on curtailment levels of variable renewable energy resources.

Research and development: Continue to promote initiatives by the industry to undertake research and development in Smart Grid technologies with a focus on piloting and testing new technologies ahead of their wide scale deployment and scaling up.

Organizational implementation: MOIT with ERAV support will establish a Smart Grid Steering Committee that will have representation of the following ministries: Finance, Planning and Investment, Science and Technology, Construction, the Viet Nam Electricity Group, and other relevant agencies / units. The purpose of the Steering Committee is to direct, monitor and oversee implementation of the Updated Smart Grid Roadmap. The Steering Committee should meet frequently to monitor the progress of Smart Grid implementation and to ensure that the ministries involved implement Smart Grid in a coordinated manner where there are overlaps in areas of responsibility. EVN Group will play a major role in ensuring that implementation actions, technology rollout and modernization activities are carried out and to ensure that the power system performance targets are satisfied by the year 2030, and to year 2050.

1.3 Expected Benefits of Updated Smart Grid Roadmap

The Updated Smart Grid Roadmap will benefit key stakeholders, including ERAV, Electricity of Viet Nam (EVN), power generation companies, transmission and distribution entities, and electricity consumers as a technology roadmap to support Viet Nam's energy transition to the year 2050. The Updated Smart Grid Roadmap plays a role in enhancing the quality and reliability of electricity supply, and the promotion of efficient utilization of energy in relation to accommodating a higher share of renewable energy in Viet Nam's power system as part of the transition towards Net Zero Emissions by 2050. The successful deployment of Smart Grid technologies will play a role in overcoming the challenges that commonly arise in power systems that have a high share of renewables including reduction in VRE curtailment, increased utilisation of transmission assets and avoidance of excessive transmission congestion, improved visibility of the power system to improve reliability and stability, overcoming the reduction in system inertia, supporting grid flexibility and enhancing end-user responsiveness and participation.

The Updated Smart Grid Roadmap is expected to guide policy development and form the basis of legislation that is required and the roll out of solutions to modernize the grid. High priority actions for the period to 2030 include early introduction of technical standards and codes, completing investments in substation automation and SCADA/EMS infrastructure to enhance monitoring and automatic control of the power system. Secondary priorities relate to the roll out of smart meters in conjunction with policies that promote prosumers and greater participation of electricity consumers in the power system.

As Smart Grids evolve there is a need for coordination between the electricity sector, building and construction sector and transport sector. To enhance coordination between these areas the Smart Grid roadmap additionally proposes to have a Steering Committee to coordinate these different areas and oversee and monitor its implementation. The Smart Grid additionally identifies the necessary regulations to govern the technologies and create incentives for their deployment to be successful. It also identifies areas of research that can be leveraged and identifies the need for capacity building to support its implementation in Viet Nam.

As such, the outcome of this project will support Viet Nam in its transition towards a more dependable, environmentally friendly, and efficient energy system, contributing to one of ETP's strategic objectives focusing on the expansion of smart grids.

This is particularly relevant for the implementation strategy section when they prioritise certain areas over the other. We should be clear on both the primary and secondary priorities.