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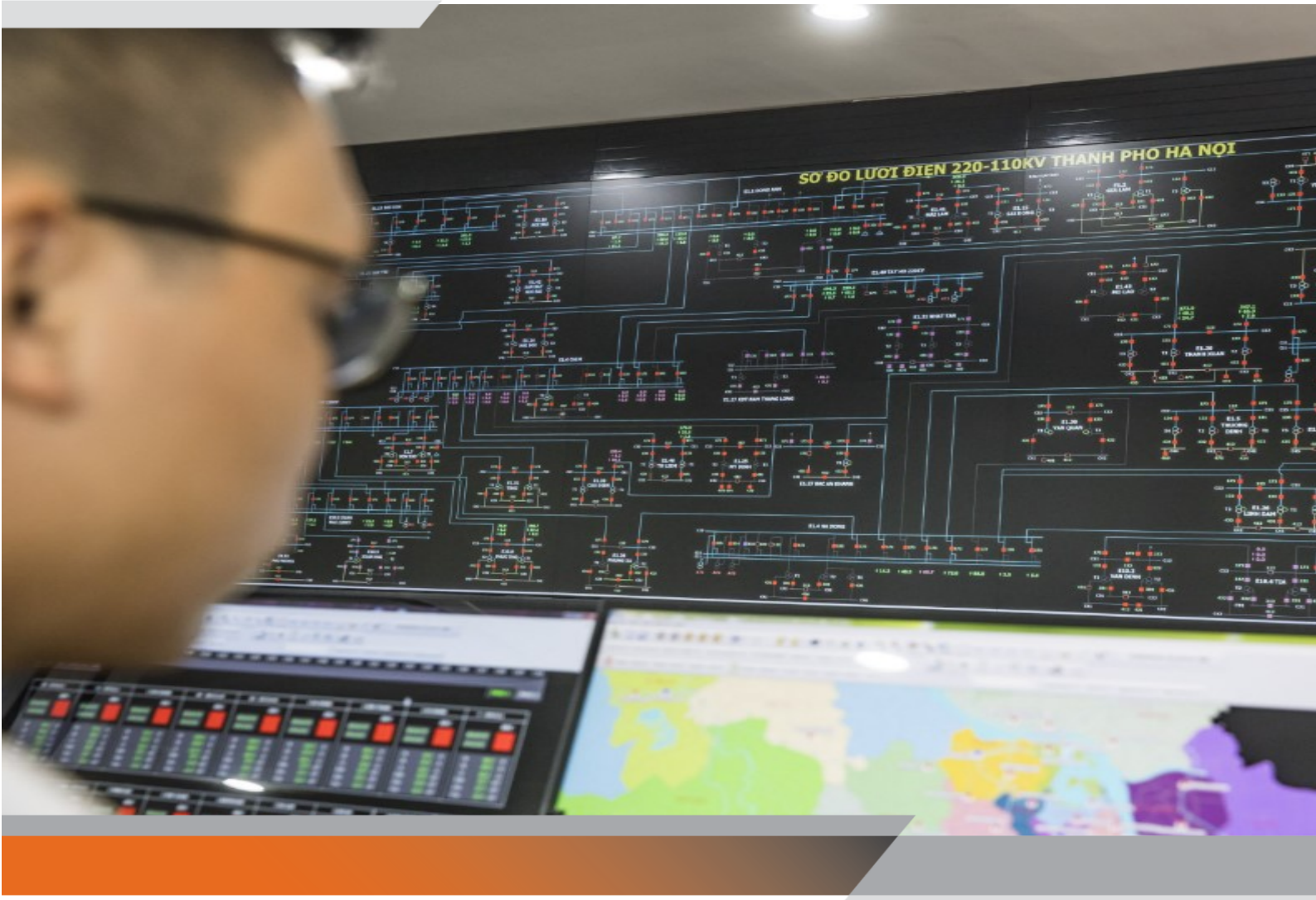

SGREEE-AA1: Revision of Viet Nam's Smart Grids Roadmap

Smart Grid Index Evaluation Methodology

Imprint

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Table of Contents

Abbreviations

ACT	Australian Capital Territory
ADMS	Advanced Distribution Management System
AMI	Advanced Metering Infrastructure
BMZ	German Federal Ministry for Economic Cooperation and Development
CEST	Central European Summer Time
DER	Distributed Energy Resources
DERlab	European Distributed Energy Resources Laboratories e. V.
DLF	Distribution Load Forecasting
DMS	Distribution Management System
DOE	USA Department of Energy
DSM	Demand Side Management
DSO	Distribution system operators
DSO	Distribution System Operator
ES	State Estimation
EU	European Union
EV	Electric Vehicles
EV	Electric Vehicles
FDI	Frequency Deviation Index
FIT	Feed-in tariff
FMSR	Fault Management & System Restoration
GDP	Gross domestic product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
ICF	International Consultant Firm
ICT	Information and Communication Technology
IEA	International Energy Association
IoT	Internet of Things
ISGAN	International Smart Grid Action Network
IT	Information Technology
KPI	Key Performance Indicator
LBFR	Load Balancing via Feeder Reconfiguration
LCF	Local Consultant Firm
LFA	Load Flow Application
LNG	Liquefied natural gas
LSA	Load Shedding Application
Mtoe	Million tons of oil equivalent
NCA	Network Connectivity Analysis
NT	Northern Territory
OFGEM	Office of Gas and Electricity Markets, UK
OT	Operational Technology
PT	Penetration Testing
RES	Renewable Energy Source
RET	Renewable Energy Target
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SGREEE	Smart Grids for Renewable Energy and Energy Efficiency project
SGRM	Smart Grid Roadmap
SLA	Service Level Agreements

TFC	Total Final Consumption
TPES	Total Primary Energy Supply
TSO	Transmission System Operator
TWh	Terawatt-hours
UFLS	Under Frequency Load Shedding
UK	United Kingdom
USA	United States of America
VDI	Voltage Deviation Index
VTR	Vulnerability, Threat, Risk
VVC	Volt-VAR Control

Acknowledgement and Disclaimer

The ‘Smart Grids for Renewable Energy and Energy Efficiency (SGREEE)’ project is supporting the Government of Viet Nam in the implementation of its Smart Grid Roadmap, which aims to promote the modernization and automation of the national power transmission and distribution system. Funded by BMZ, the project is working closely with ERAV to support experts of the Vietnamese power sector in developing a “Smart Grid”, i.e. the digitalization and flexibilization of the power supply system, which allows integration of an increasing share of renewable energies and supports greater energy efficiency.

Executive Summary

Executive Summary

This report presents the methodology and the work plan proposed by DERlab to analyse the Viet Nam Smart Grid Roadmap. Furthermore, it gives an overview of the countries that have been selected to present international best practice.

Methodology

The methodology proposed by DERlab in this project is based on the Smart Grid Index methodology that was introduced by SP Engineering Council, SP Group, Singapore. DERlab introduces an additional index which is "Energy Market" to support Viet Nam with its plan from shifting from the wholesale energy market to the retail market. This methodology consists of eight indexes that cover the whole Smart Grid spectrum.

Chapter

01

Introduction to the assignment

1. Introduction

As one of the most dynamically growing economies in Asia, Viet Nam faces an enormous increase in energy demand that will continue to grow at a double-digit rate in the coming years. Although there are constant investments in generation and grid infrastructure, reliability and security of electricity supply remain substantial challenges for the Vietnamese power system, especially in the period of the dry season.

The Vietnamese Government has issued decision No. 1670/QD-TTg in 2012 on the development of Smart Grid in Viet Nam (in short: Smart Grid Roadmap: SGRM). The SGRM set a general target for Smart Grids to improve system reliability through demand-side management (DSM) and energy efficiency measures. With the help of advanced Smart Grid technologies, the plan envisages improving grid reliability and power supply, enhance DSM and thereby reduce the need or defer network investment and encourage a more system-efficient integration of Renewable Energy Source (RES) and other technologies.

1.1 The project objective

After 9 years of implementing Smart Grid Roadmap, there has been reportedly differences and challenges during implementation, those need to be adjusted in an official format.

The bilateral project Smart Grids for Renewable Energy and Energy Efficiency (SGREEE) supports the Government of Viet Nam in the implementation of its Smart Grid Roadmap with the immediate aim to facilitate the integration of an increasing share of Renewable Energy as well as enable advanced demand-response by introducing intelligent grid solutions.

DERlab and the local consultant (BKContech) have been subcontracted under the SGREEE project to evaluate the current Viet Nam Smart Grid Roadmap and identify the current and future challenges that are facing the Vietnamese electric energy system. Based on that some recommendations and international best practices will be provided to the Viet Nam stakeholders.

Chapter

02

Methodology

2. Methodology

This chapter presents the methodology that is going to be used to analyse the Vietnamese electric energy system. Based on this analysis gaps and challenges will be identified and recommendations from best practice countries are going to be recommended to update the Smart Grid Roadmap for Viet Nam.

2.1 Introduction to the 8 Smart Grid Index

The methodology proposed by DERlab in this project is based on the Smart Grid Index that was introduced by SP Engineering Council, SP Group, Singapore [1]. DERlab introduces an additional index which is "Energy Market" to support Viet Nam with its plan from shifting from the wholesale energy market to the retail market. Figure 1 presents the Smart Grid Indexes that are going to be used in this project.

Figure 1: Smart Grid Index

2.1.1 Monitoring and control

As the electric network becomes increasingly complex, a real-time network view and dynamic decision-making capabilities have become crucial for optimizing resources and managing the network. Supervisory Control and Data Acquisition (SCADA) system is commonly used by utilities for data acquisition, monitoring and control of the entire transmission and distribution network.

The Distribution Management System (DMS) acts as a decision support mechanism assisting the control room and field operating personnel, in which real data is processed and vital information is provided. The next level of DMS is commonly known as Advanced Distribution Management System (ADMS) which includes automatic fault location, isolation and supply restoration capabilities, and an integrated outage management system in the event of network failure.

With the increase of the penetration of renewable energy sources at the distribution level, the network power flow has transformed from a unidirectional power flow to a bidirectional power flow. This creates additional challenges for the Distribution System Operator (DSO) and Transmission System Operator (TSO). The TSO and DSO need to interact with each other to improve the network operation and planning and increase the reliability of the network.

This monitoring and control index is divided into three main sub-indexes which are:

1. SCADA system
2. DMS/ADMS and its application
3. TSO/DSO interaction

SCADA System

SCADA system is used by TSO and DSO to monitor and control their network. Under this sub-index, ICF and LCF will analyse to which extent the SCADA system is used to monitor and control Viet Nam's electric grid and on which voltage levels it is used. One point will be given for each voltage level. The maximum number of points given under this sub-index are three points.

DMS/ADMS and its application

Under this sub-index, the applications and functionalities that are used to monitor and control the entire network efficiently would be analyzed. Those applications and functionalities support the grid operator in decision making, operation and maintenance activities. Nine applications and functionalities are analyzed. One point will be given for each application/functionality and the maximum number of points given under this sub-index are nine points.

- *Network Connectivity Analysis (NCA)*: It is an operator-specific functionality that helps the operator to identify or locate the network component easily. NCA displays the feed point of various network loads and its switching devices such as circuit breaker, Ring Main Unit, and isolators that affect the grid topology.
- *Switching Schedule & Safety Management:* This functionality is used to support safe switching and work on the network. The control engineers prepare the switching schedules to isolate and make safe a section of the network before work is carried out. When the required section has been made safe, the DMS allows a permit to work document to be issued. When the work is completed, the switching schedule facilities the restoration to normal operation.
- *State Estimation (ES):* The State Estimation is used to provide a reliable estimate of the system voltage. The information from the state estimator flows to control centres and database servers across the network. It allows the calculation of the interesting variables despite the facts that the measurements may be corrupted by noise, or could be missing or inaccurate.
- *Load Flow Application (LFA):* The Load Flow study is an important tool involving numerical analysis applied to the power system. It analyses the power system in normal steady-state operation. Load-flow is important for planning future expansion of power systems as well as determining the best operation of existing systems.
- *Volt-VAR Control (VVC):* This control functionality manages voltage levels and reactive power (VAR) throughout the power distribution systems. There are three primary tools for carrying out voltage management: Load-tap changers, voltage regulators and capacitor banks.
- *Load Shedding Application (LSA):* Automatic load shedding application detects predetermined trigger conditions in the distribution network and performs predefined sets of control actions, such as opening or closing non-critical feeders, reconfiguring downstream distribution or sources of injections or performing a tap control at a transformer. The application should also cover various activities like Under Frequency Load Shedding (UFLS).

- *Fault Management & System Restoration (FMSR):* Reducing the outage time duration to the customer, shall improve overall utility reliability. There are two main features required by the FMSR: Switching managing & Suggested switching plan. The DMS application receives faults information from the SCADA system and processes the same for identification of faults and on running switching management application. The results are converted to an action plan by the application and the results are converted to action plans by the application. The action plan includes switching ON/OFF the automatic load break switches. The switching management can be manual/automatic based on the configuration.
- *Load Balancing via Feeder Reconfiguration (LBFR):* This application is essential for utilities where they have multiple feeders feeding a load congested area. To balance the loads on a network, the operator re-routes the loads to other parts of the network. The feeder load management monitors the vital signs of the distribution system and identifies areas of concern so that the distribution operator is forewarned and focus attention where it is most needed. In addition to that, the feeder reconfiguration is also used for loss minimization. Due to several networks and operational constraints utility network may be operated to their maximum capacity without knowing its consequences of losses occurring.
- *Distribution Load Forecasting (DLF):* It provides a structured interface for creating, managing and analyzing load forecasts. Accurate models for electric power load forecasting are essential to the operation and planning. Load forecasting is classified in terms of different planning durations: short-term load forecasting (up to one day), medium-term load forecasting (one day to one year) and long-term forecasting (one to ten years).

TSO/DSO interaction

The interaction between TSO and DSO to solve grid challenges is a new emerging topic in which a lot of research is taking place. Under this sub-index, the LCF and ICF will analyze how the TSO and DSO interact to solve the grid operation challenges e.g., grid congestion, voltage support and ancillary services and what kind of data does TSO and DSO exchange. One point will be given for each challenge. The maximum number of points given under this sub-index are three points.

Under this index, the monitoring and controlling for the Vietnamese transmission and distribution systems will be analyzed and recommendation from international best practice will be provided to the stakeholders within the frame of this project. This index is divided into three sub-indexes: SCADA, DMS/ADMS and TSO/DSO interaction. Three points are given to the SCADA system, nine points are given to DMS/ADMS and three points are given to TSO/DSO interaction. The total number of points are 15 points. Figure 2 presents a chart that is going to use to evaluate Viet Nam in comparison to other countries.

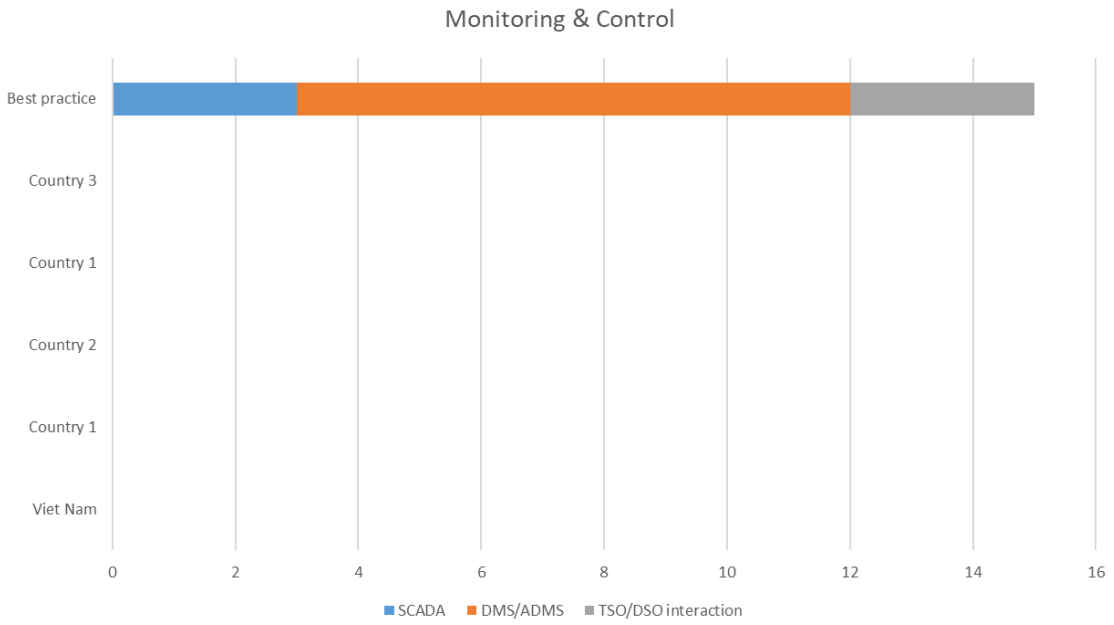

Figure 2: Monitoring & control chart

2.1.2 Data Analytics

The Advanced Metering Infrastructure (AMI) is an integrated system of smart meters, communication networks and meter data management systems. These smart devices enable the grid operators to monitor the status of low voltage networks, which are typically not monitored under SCADA.

The implementation of AMI will lead to a huge volume of data collected. This big data needs to be analyzed to produce useful results that could support the grid operators to improve the operation and maintenance of the electric grid. Furthermore, utilities can use data analytics to better understand customer behaviour, consumption patterns, network reinforcement and asset renewal needs.

Under this index, three sub-indexes will be analyzed. The first sub-index focuses on the percentage of smart meters installed in the country and its value will be presented in percentage (0% to 100%) based on the percentage of Smart Meter roll-out. The second sub-index focuses on the data collected by the Smart Meters and how the data is analyzed. The value of this sub-index will be presented in percentage based on the data collected and to which extend this data is used. The third sub-index focuses on the functionalities of the smart meter used.

Smart Meter roll-out
This sub-index focuses on the percentage of smart meters installed in Vietnam and what is the plan for smart meter roll-out.

Data collection and analytics
This sub-index focuses on the data collected by the smart meter e.g., voltage, current, power (4 quadrants), harmonics, and power factor and how the data is analyzed e.g., is the data used for networking planning? Is the data used for scheduling maintenance and asset renewal?

Smart Meter Functionalities

This sub-index focuses on the functionalities of the Smart meters installed. The following functionalities are going to be addressed and analyzed:

- Automatic billing system & dynamic tariffs
- Real-time monitoring
- Demand response & load control functionalities
- Outage detection
- Losses & theft detection

Under this sub-index, the smart metering system for Vietnam will be analyzed and recommendations from best practice will be proposed. Figure 3 presents the chart that is going to be used to compare Viet Nam to other countries and best practice.

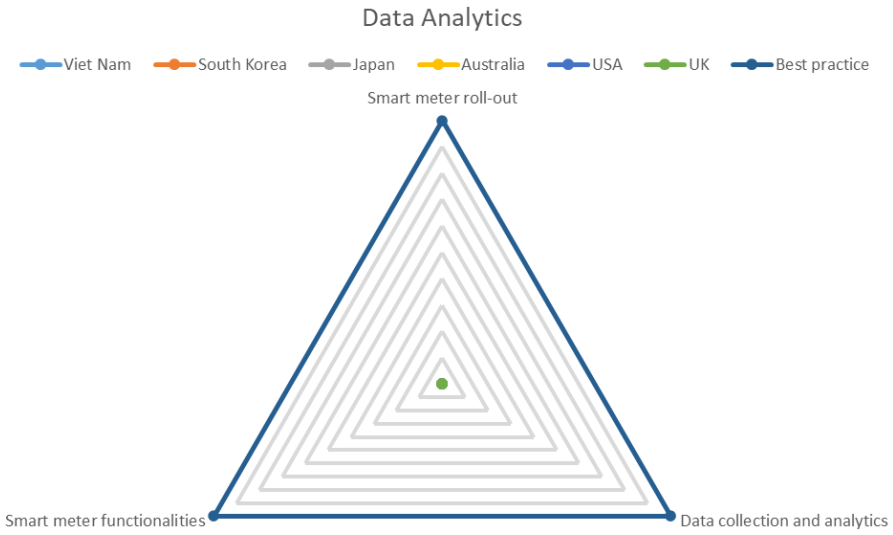

Figure 3: Data Analytics chart

2.1.3 Supply Reliability

Supply reliability is a key performance index to measure the reliability and the power quality of the electricity delivered to the end customer (e.g., SAIDI, SAIFI, voltage, frequency). Under this index, the KPIs for monitoring the electric system will be analyzed. This index will be evaluated from nine points.

SAIDI

This KPI used to analyze the system reliability is SAIDI (System Average Interruption Duration Index) which corresponds to the average interruption duration per year. It calculated by the following equation:

$$SAIDI = \frac{\sum(r_i N_i)}{N_T}$$

The summation is taken over all incidents in one year, either at all voltage levels or only at selected voltage level; r_i is the restoration time for each incident; N_i is the number of customers affected by each incident; N_T the total number of customers in the system for which the index is calculated. The results are expressed in minutes lost per customer per year [2]. This sub-index will be evaluated from two points. One point will be given in case SAIDI is monitored on an annual basis and another point will be given in case the value for SAIDI is below the international average and it is decreasing on an annual basis.

SAIFI

This KPI used to analyze the system reliability is SAIFI (System Average Interruption Frequency Index) which corresponds to the average number of interruption times per year. It is calculated by the following equation:

$$SAIFI = \frac{\sum N_i}{N_T}$$

The results are expressed in the number of interruptions per customer per year [2]. This sub-index will be evaluated from two points. One point will be given in case SAIFI is monitored on an annual basis and another point will be given in case the value for SAIFI is below the international average and it is decreasing on annual basis.

Frequency Deviation Index (FDI):

This KPI indicates the frequency deviation beyond a certain range from the nominal supply frequency. This range is defined in the grid code. Any frequency excursions outside these limits are recorded as frequency limit violations. The frequency deviation indicators are defined by the number of times and duration that the system frequency goes beyond the allowable range [3]. This sub-index will be evaluated from two points. One point will be given in case FDI is monitored on an annual basis and another point will be given in case the value for FDI is below the international average and it is decreasing on annual basis.

Voltage Deviation Index (VDI):

This KPI indicates the voltage deviation beyond the allowed range in standards and grid code. This voltage deviation can be identified by monitoring the bus bar voltages of the grid substations. The voltage deviation indicators are defined to find the frequency and duration that the bus bar voltages violate the allowed voltage range [3].

- Number of voltage violation per year
- Percentage of time that the voltage violated the permissible limits

This sub-index will be evaluated from two points. One point will be given in case VDI is monitored on an annual basis and another point will be given in case the value for VDI is below the international average and it is decreasing on annual basis.

Mitigation plan

In addition to analyzing the supply reliability of the electric grid, mitigation plans to increase the grid reliability and to prevent outages will be introduced as recommendations from international best practices. One point is going to be given under this sub-index, in case there is a mitigation plan to increase the grid reliability.

Figure 4 presents a chart is going to be used to compare Viet Nam to other countries and best practice in supply reliability index.

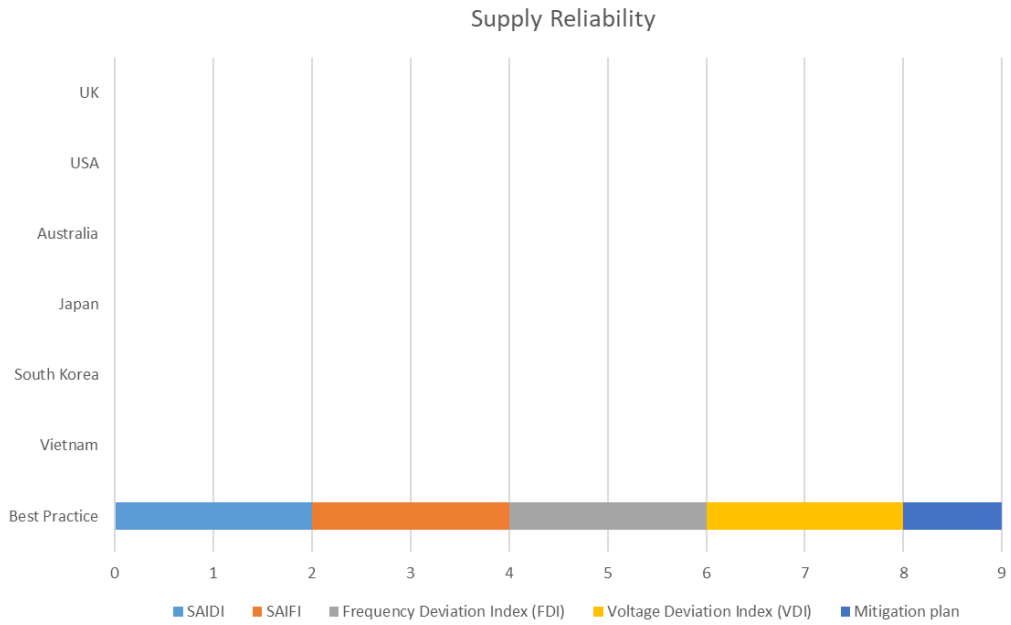

Figure 4: Supply Reliability chart

2.1.4 DER Integration

Distributed Energy Resources (DER) refers to all renewable resources and energy storage systems connected to the electrical distribution network. Due to the intermittent nature of solar and wind energy, energy storage and flexible loads are introduced to solve the problem of variability. Nonetheless, the integration of DERs into the grid remains challenging in smart grid development.

To support the grid operators and utilities with the challenges introduced by the variable renewable energy, new tools, communication sensors, data platforms and artificial intelligence needs to be deployed into the system.

Under this index, there are two sub-indexes. The first sub-index focuses on connection code and requirements for distributed renewable energy resources and how DER supports the grid in providing ancillary services. The second sub-index focuses on providing flexibility to the grid via different means e.g., energy storage, Power-to-Gas and flexible loads. Each sub-index has a maximum score of three points.

Distributed Energy Resources (DER):
This sub-index focuses on the connection code and requirements for distributed renewable energy resources. This sub-index would be addressed from three prospective. The first one focuses on whether the regulation allows renewable energy to be connected to the grid or not. The second one focuses on grid codes and requirements for connecting DER to the grid. The last one focuses on the ancillary services that are provided by DER. A point will be given for each topic and the maximum score for this sub-index is three points.

Flexibility
Under this sub-index, flexibility to the electric energy system is analyzed from three different perspectives. The first one focuses on battery storage and how it is used to provide flexibility. The second one focuses on power-to-gas technology (e.g., Green hydrogen) and how it used to provide flexibility. The last one focuses on flexible loads

connected to the electric grid and how they provide flexibility. A point will be given for each topic and the maximum score for this sub-index is three points.

Under this index, DERlab and the local consultant will focus on how to manage the electric grid with a high share of renewable energy and will introduce recommendations from international best practice to address the challenges. Figure 5 presents a chart is going to be used to compare Viet Nam to other countries and best practice under DER integration index.

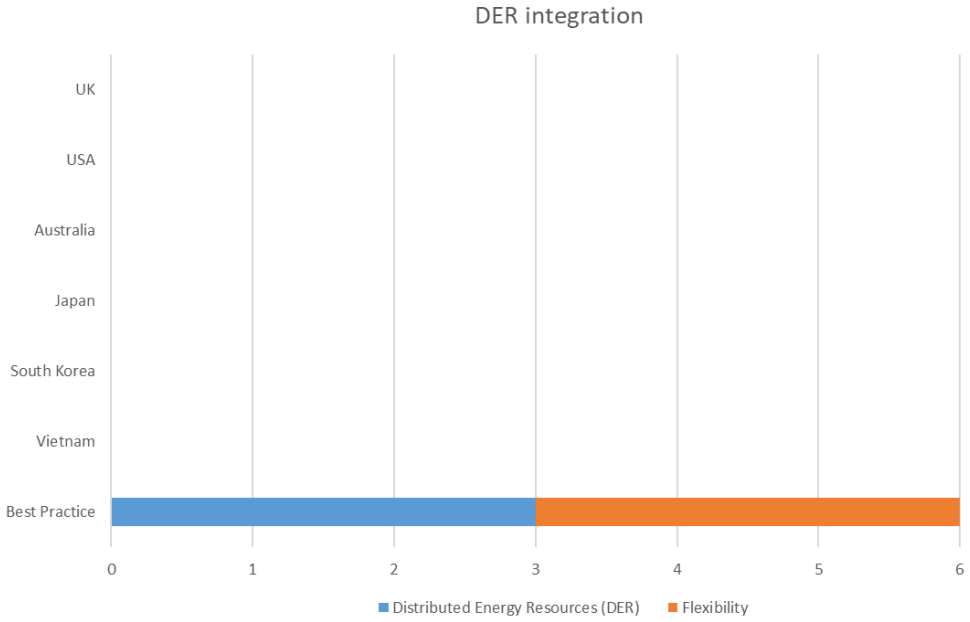

Figure 5: DER integration chart

2.1.5 Green Energy

Renewable energy resources are considered to be one of the most promising solutions to reduce greenhouse emission and limiting the increase in global average temperature.

According to the International Energy Association (IEA), the transportation sector represents about 20% of greenhouse emission [4]. Electrifying the transportation sector would help to reduce greenhouse emission, especially when the electric grid has a high share of renewable energy. Utilities can promote electric vehicles (EV) by installing charging stations infrastructure for the public. Smart charging for EVs encourages customers to charge their vehicles during off-peak hours when electricity demand is low or when there is a lot of electric energy is produced from renewable energy resources. This can help to reduce the peak load demand and provide flexibility to variable renewable energy resources.

Under this index, the penetration of renewable energy resources and their impact on reducing greenhouse emission will be analyzed in Viet Nam. Furthermore, electrifying the transportation sector will be introduced based on international best practice. In addition to that energy efficiency programs in Viet Nam will be analyzed and recommendations will be proposed to accelerate the reduction of greenhouse emission in Veit Nam.

This index is divided into four sub-indexes which are: generation, energy efficiency, electric mobility and environment. Each sub-index will be evaluated in percentage. Figure 6 presents the chart that is going to be used to compare Vietnam to other countries and best practice under the Green Energy index.

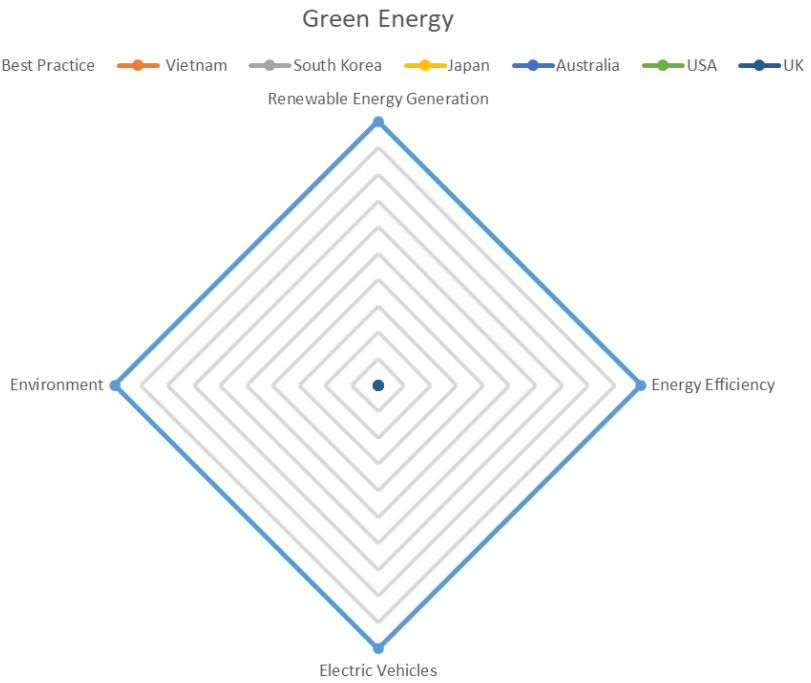

Figure 6: Green Energy chart

2.1.6 Cybersecurity

Many organizations, including utilities, around the World, have suffered from Cybersecurity attacks. Utilities must exercise extreme caution to deal with cyber threats as more Internet of Things (IoT) devices are deployed in the network. Security of the grid telecommunication, operation and control systems should be a top priority; stringent cybersecurity measures, including compliance to cybersecurity standards for both Information Technology (IT) and Operational Technology (OT) systems, are crucial for the security of the grid.

Under this index, the resilience of the electricity system against cyber-attacks will be analyzed and recommendation based on the state of the art will be recommended to protect the system against cyberattacks.

In this index, the term 'Organization' has been defined as an electricity generation company, transmission company, distribution company or load dispatch centre. Also, the 'IT system' may need to be treated as 'IT and OT (Operational Technology) systems' wherever applicable. The list of questions given in the annex for cybersecurity is explained below in detail to assist in answering the questionnaire to the stakeholders. This index is measured in terms of percentage where 0% relates to no cybersecurity existing within the organization and 100% relates to in line with the state of the art.

Formulation of risk-based cybersecurity policy
In the power sector, cyberspace security is the protection of data, systems, and infrastructure vital for the organization's operation, stability and livelihood of people

associated with the organization. Organizations are increasingly depending on Information and Communication Technology (ICT). Along with the growing economic value of ICT for organizations, threats to it are all growing because of the increased connectivity. A secure organization can be confident that it is better positioned for opportunity and growth. To ensure a secure environment, a strategy to protect the organization's cyberspace is required for managing risks and boosting resilience. Organizations must build and implement a risk-based cybersecurity policy with clear priorities, minimum ICT security baseline with threat and vulnerability information, build incident response capabilities and create awareness, educating and training opportunities.

Protection of portable/wireless/removable media
This security control defines a formal procedure to prevent the use of unnecessary logical and physical input/output ports used for network connectivity, console commands, or removable media. It is required to minimize the attack surface by disabling or limiting access to unnecessary physical and logical access ports and services.

White/Black/Grey Listing
Restrictions are generally defined by rules that whitelist and/or blacklist traffic based on some factors including source addresses, destination addresses, and content (e.g., deep packet inspection). Whitelisting/Blacklisting becomes important in the scenarios where other malware protection tools are not recommended for use in the offered automation solution for various reasons.

Access Control (including Remote Access)
It addresses the requirement of a management process for controls to ensure effective and secure access control. These controls apply to local or remote access to system hardware or devices as well as remote access to the same. It also includes restrictions on user access.

Account management
It addresses the requirement of a management process for controls to ensure effective and secure account management. The account management controls shall support the enforcement of security policies either as a whole or selectively. i.e., account management controls shall include authentication as well as authorization.

Patch management
It addresses the requirement of a management process for tracking, evaluating and installing patch updates for the applicable assets. This may even include the identification of a source (sources) releasing the patches.

Information protection (including data protection)
This security control defines a formal procedure for information protection mechanism including data residing on storage, disk drives (both internal/external), desktops/laptops, Servers, LTOs, etc. The value of the data that requires protection and the system storing the data need to be considered carefully. An in-depth approach is recommended when evaluating and deploying encryption methods. This approach applies to both data at rest and in transit.

Internal and external audit

Regular internal and external audit for cybersecurity must be conducted by the organization. It is advisable to change the auditors regularly. Vulnerability, Threat, Risk (VTR) assessment and Penetration Testing (PT) need to be integrated as part of internal and external cybersecurity audits. VTR assessment and management is an ongoing process and must be reviewed regularly. Penetration testing for communication network and public-facing web portal/services should be carried out at regular intervals.

Cybersecurity SLAs

Smart grid has made traditional grid operations to be more reliant on IT infrastructure for system monitoring, control, computing and communication requirements. Third-party IT services like data backup, cloud computing and communication infrastructure support are being outsourced. Cybersecurity Service Level Agreements (SLAs) can help reduce risk to the organization while outsourcing such operational requirements. Also, well-negotiated SLAs are of great help in post-incident legal combat.

The organization must insist on specific and enforceable stipulations in SLAs in compliance with controls and standards to which the organization is committed. A management-level framework is needed to monitor compliance of SLAs.

Security certification

Third-party security certification is needed to validate the security measures adopted by the organization for protecting its IT and OT infrastructure. The third-party certifying agency may be a government agency, or an agency empanelled/recommended by the competent government authority.

Process of security certification needs to be carried out according to national/international standards (OT security standards such as NERC-CIP, NIST, ISO 27019, IEC 62443 etc. and IT security standards such as ISO: 27001, NERC CIP, NIST etc.) as specified by the competent authority and need to be reviewed regularly to incorporate new controls released from time to time. The recommendations of the certifying agency need to be implemented and a mechanism needs to be evolved at the organization level to monitor its impact on the security enhancement.

Security awareness training

A formal procedure for educating the appropriate personnel in the organization about cybersecurity. A security awareness program is made to educate the personnel about the strategy, policies and procedures defined by the organization. The skills and knowledge thus acquired will be vital forces for the growth of the organization.

Personnel risk assessment

Personnel risk assessment is an integrated cybersecurity control that deals with the safety and security of critical information from unauthorized personnel and unauthorized access. It accounts for the risks that the personnel could pose to the organization. It also helps the senior officials in the organization to identify the risks to which the organization is exposed and hence respond appropriately to mitigate such risks.

Monitoring and review policy

Monitoring and review of security policies is a vital part of the policy framework, as it is required to fill the loopholes. It provides an opportunity for the organization to keep updating its security posture through regular checks, thus making the security controls and policies more effective.

Contingency plans
It addresses the requirement of a documented management process for contingency plans to ensure that the effect of a security breach or incident is minimal and does not affect the business processes of the organization. It encompasses crisis management, business continuity and disaster recovery. It also includes the learnings and remedial actions in terms of mitigating the vulnerabilities that were exploited, to prevent similar incidents in future.

Incident response management system
Incident response management systems are employed to deal with critical events when a security breach has already taken place or in an emergency. These incidents can lead to serious damage to the critical data which the organization houses and consequently to the security of the organization. An incident can be a network or computer attack, an environmental one or a physical security attack.

2.1.7 Customer Empowerment & Satisfaction

AMI enables utilities to provide customers with real-time energy consumption data and pricing information. This would create greater awareness for customers about their energy usage and enable them to manage their consumption and lower energy costs. Moreover, it is important to conduct regular customer satisfaction surveys to better understand the customers' needs and satisfy them.

This index consists of two sub-indexes which are customer empowerment and customer satisfaction. The customer empowerment will focus on allowing the customer to monitor his/her energy consumption in real-time and control his/her appliance. In addition to that, customer engagement in the demand response campaign will be analyzed. Furthermore, changing tariffs and retailer will be analyzed.

Under the customer satisfaction sub-index, ICF will analyze whether surveys are conducted to measure the degree of customer satisfaction and whether customer feedback is taken into consideration to improve the service. Figure 7 presents the chart that is going to be used to compare Vietnam to other countries and best practice under the customer empowerment & satisfaction index.

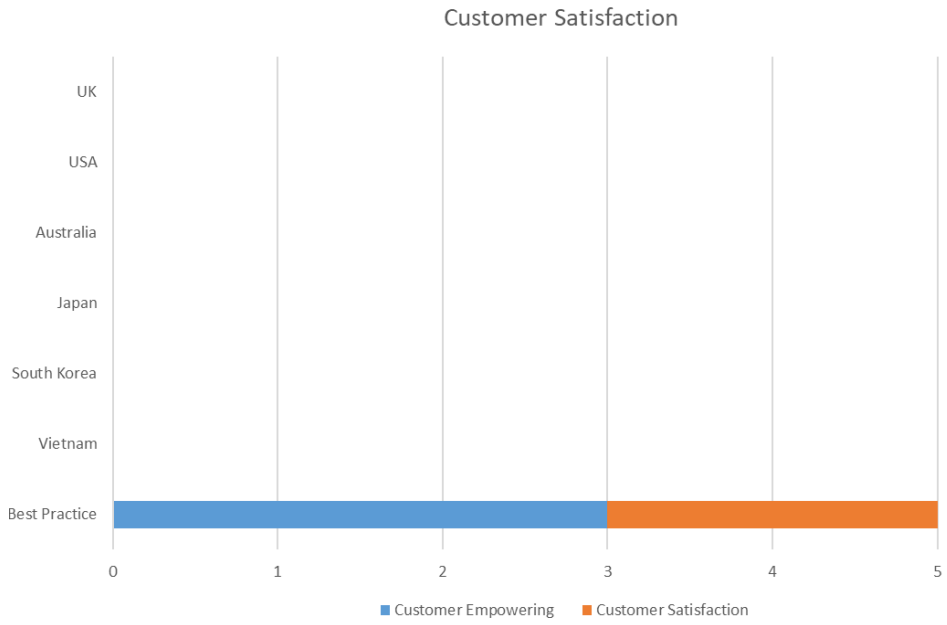

Figure 7: Customer satisfaction & empowering chart

2.1.8 Energy Market

The energy market is commodity markets that deal specifically with the trade and supply of energy. The energy markets have been liberalized in different countries around the world to protect customer rights and avoid oligopolies. Furthermore, new markets have been introduced to provide grid operators with ancillary (e.g., frequency regulation). Under this index, the energy market in Viet Nam will be analyzed and recommendations based on international best practice will be presented.

2.1.9 Grading system

To be able to compare Vietnam to other countries a grading system has been created to measure the smart grid readiness level. It is calculated for each country by summing up the ratio grade under each index and dividing it by eight. The results are presented in percentage.

$$Country\ smart\ grid\ readiness = \frac{\sum_{i=1}^{8} \frac{index\ grade}{index\ best\ practice\ grade}}{8}\%$$

3. Conclusion

In conclusion, this document presents the methodology and work plan proposed by DERlab to analysis the current Smart Grid roadmap and identify the gaps and challenges. Moreover, it would position Viet Nam Smart Grid development in comparison to other countries. Furthermore, DERlab would propose some recommendations at the end of the project to update and improve the Viet Nam Smart Grid Roadmap.

The methodology proposed by DERlab in this project is based on the Smart Grid Index methodology developed by the SP group in Singapore. DERlab modified this methodology by introducing the "Energy Market" index. This index would support Viet Nam in its plan from shifting from the wholesale energy market to the retail market.

DERlab recommends dividing the project into eight sprints. Under each sprint, a smart grid index will be analyzed and recommendations from international best practice will be provided. The duration for each sprint should last two weeks.

Five countries, members of the International Smart Grid Action Network (ISGAN), have been selected to present international best practice. Those countries are South Korea, Japan, Australia, the USA and the UK.

Chapter

03

Annex

Questions for local stakeholders

3.1. Monitoring & Control

- Is the SCADA system used by TSO & DSO to monitor and control UHV/HV/MV/LV?
- Which DMS/ADMS applications are integrated into the SCADA system? A list of application and its description is presented in section 2.1.1 Monitoring and control
- What are the tools used by DSO and TSO in Vietnam to identify or locate network component e.g., circuit breakers, transformer monitoring etc.?
- In case maintenance takes place, what are the safety protocols taken to secure the workers? And are there any tools/applications used for that?
- Is the state estimator used by TSO and DSO in Vietnam to provide information on the voltage at each point in the network?
- Is the load flow application used by TSO and DSO in Vietnam to analyse the power system?
- Which tools used by TSO and DSO in Vietnam to manage the voltage in the network?
- Does distributed renewable energy resources plays a role in stabilizing the grid voltage? And what is this role?
- Is the automatic tap changer used to manage the voltage? What is the percentage of transformers with automatic tap changer?
- Which tools used by TSO and DSO in Vietnam for load shedding?
- Which tools used by TSO and DSO in Vietnam for fault management & restoration? Do those tools automatically detect faults and restore them automatically?
- Which tools used by TSO and DSO in Vietnam for load balancing?
- Do DSO and TSO in Vietnam use any tool or application to minimize grid losses?
- Which tools used by TSO and DSO in Vietnam for load forecasting and generation planning?
- Is load forecasting done on 15 minutes / hourly / daily / weekly / monthly / yearly / 10 years based?
- Which tools are used for forecasting renewable energy generation?
- Is there regulation defined for the interaction between TSO and DSO to face the following challenges: congestion management, voltage and ancillary services?
- Do DSO and TSO share their grid model and grid topology with each other?
- How TSO and DSO manage congestion within their network? Do they support each other in congestion management?
- How DSO supports the TSO in providing ancillary services?
- Does the power system has the capability to operate in a microgrid fashion during the outage with the help of black start capability from renewable resources?

3.2. Data Analytics

- What is the percentage of smart meter roll-out in Vietnam?
- Does the smart meter install measure the power in four quadrants?

- Does the smart meter install measure the current in four quadrants?
- Does the smart meter install measure the voltage in four quadrants?
- What is the time resolution of the smart meter installed? 1 reading every 1 sec./1 min./15 min./1 hour/24 hours
- Does the smart meter install measure total harmonic distortion?
- Does the smart meter install measure the power factor?
- Is the data collected by the smart meters used for networking planning?
- Is the data collected by the smart meters used for maintenance and asset renewal?
- Is the data collected by the smart meters used for analyzing the customer behaviour & his consumption patterns?
- Would it possible to share with us the datasheet for the smart meters installed in Vietnam?
- Do the smart meters install in Vietnam have automatic billing system functionality and dynamic tariffs?
- Can the end-user monitor his/her energy consumption in real-time via a mobile app or web interface?
- Can the DSO monitor the energy consumption per smart meter user in real-time?
- Do the smart meters install in Vietnam offer demand response or load control service?
- Can the smart meters installed in Vietnam detect outage?
- Can the smart meters installed in Vietnam detect non-technical losses (Electricity theft)?

3.3. Supply Reliability

- The SAIDI & SAIFI figures have increased in EVNNPC (& EVN), is there a clear reason behind that?
- How is SAIDI & SAIFI are calculated in Vietnam? Is it the same methodology as presented in the Inception report?
- Do the SAIDI & SAIFI results include all DSOs & TSOs in Vietnam?
- Are frequency deviation indexes measured/calculated in Vietnam?
- If yes, how often the frequency deviates beyond its limits within a year?
- If yes, for how long does the frequency deviate beyond its limits within a year?
- Are voltage deviation indexes measured/calculated in Vietnam?
- If yes, how often the voltage deviates beyond its limits within a year?
- If yes, for how long does the voltage deviate beyond its limits within a year?
- Is there a mitigation plan to prevent/reduce outages?
- If yes, what are those mitigation plans?
- Does the power quality (such as flicker, harmonics, etc.) at the point of common coupling always within the stipulated standard (national/international)?

3.4. DER integration

- Is there regulation allowing PV, Wind, Bioenergy and Hydropower to be connected to the electric grid?

- Is there grid codes or connection requirement defining how DER are connected to the electric grid?
- Does DER provide ancillary services to the electric grid? what ancillary services do they provide?
- What kind of technology used for PV inverters? Is it grid feeding or grid supporting or grid forming inverters?
- Are batteries used to provide flexibility to the electric energy system?
- What is the capacity of batteries in MW and MWh connected to the electric grid?
- Are those batteries connected alone to the grid or together with renewable energy sources?
- At what voltage levels are those batteries connected to the grid?
- Is there a grid code for batteries?
- Is Power-to-gas technology (e.g., Green Hydrogen) used to provide flexibility to the electric grid?
- If yes, what is the capacity of power-to-gas technology?
- If no, are there any plans?
- Are there flexible loads that are connected grid a provide flexibility? What is their capacity?

3.5. Green Energy

- What is the capacity of renewable energy installed per technology?
- What is the capacity of non-renewable energy installed per technology?
- How much energy is generated by each renewable energy technology?
- How much energy is generated by each non-renewable energy technology?
- What is the energy target for Vietnam?
- Is there an energy efficiency program in Vietnam?
- Does this energy efficiency program focus on residential or industrial users or both?
- Is there a strategy plan for electric mobility in Vietnam?
- How many electric vehicles are currently available on Vietnam's streets?
- How many charging stations are currently installed in Vietnam? and it's capacity?
- Do any of them have smart charging or V2G functionalities?
- Which charging standards are used in Vietnam?
- What is the current CO2 emission per kWh generated in Vietnam?
- Is there a strategy target reduce CO2 emission?

3.6. Cybersecurity

- Is there any formulation of a risk-based cybersecurity policy?
- Is there any protection considered for portable/wireless/removable media?
- Is there any way to differentiate white-/black-/greylisting so that the severity of the threat could be differentiated?
- Do you secure access control including remote access to system hardware or devices?
- Is there any management process or standard available to ensure secure account management?

- Are they updating their software on regular basis?
- Is there any information protection considered including data storage?
- Is there any internal or external audit conducted for cybersecurity within the organization?
- Are there any cybersecurity service level agreements (SLAs) existing to reduce the risk while outsourcing operational requirements?
- Is there any security certification adopted by the organization to protect Information technology (IT) and operational technology (OT) infrastructure?
- Is there any security awareness training to educate the personnel about cybersecurity?
- Is there any personnel risk assessment existing from unauthorized access?
- Any existing monitoring and review policy to keep updating its security postures?
- Any contingency plans existing to make sure the security breach minimal?
- Any incident response management system existing to deal with critical events during a security breach?

3.7. Customer Empowerment & Satisfaction

- Can the end-user monitor his/her energy and power consumption in real-time via a mobile app or web interface?
- Can the end-user change his/her tariff based on his/her needs?
- Can the end-user choose between different energy retailers?
- Can the end-user control his/her home appliances remotely via an app?
- Is the end-user engaged in demand response campaigns?
- Does the end-user get benefits when he/she is engaged in demand response?
- Is customer satisfaction surveys conducted regularly? If yes, what is the rating?
- Is there any regulation to protect the customer data?

3.8. Energy Market

- How many DSO, TSO and retailers are in Vietnam?
- Is there a spot energy market organizing the energy generation-based merit order?
- Is there an energy market for ancillary services?
- If yes, what is the pre-qualification for the energy market for ancillary services?
- Is there a business model used for the demand response campaign?
- How the load is forecasted in the day-ahead market?

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