Abstract – Provincial Electricity Authority (PEA) has engaged in the development of Smart Grids. Smart Grids is the future of electric power system and electricity supply businesses. A development process of Smart Grids is continuous and collaborative and involves several stakeholders. A clear picture of Smart Grids enables all stakeholders to accelerate the development process. Roadmapping is a way of imaging and expecting a series of future pictures at different points of time. This paper shows the application of roadmapping in visualizing the PEA Smart Grids.

Keywords – Organizational Capabilities, roadmap, Provincial Electricity Authority, roadmapping, smart grids.

1. INTRODUCTION

Electric utilities in many countries have developed their electrical power system (EPS) for their customers and societies in a digital era. Main driving forces of development are increasing demand for electricity, power quality and reliability improvement, environment conservation, and operation excellence. The future EPS is aimed at integrating the actions of all users connected to it – electricity producers and consumers and those who do both – in order to efficiently deliver sustainable, economic and secure electricity supplies. The future EPS, called Smart Grids, have characteristics of (i) self-healing and adaptive, (ii) interactive with consumers and markets, (iii) optimised to make best use of resources and equipment, (iv) predictive to prevent emergencies, (v) distributed across geographical and organisational boundaries, (vi) integrated, merging monitoring, control, protection, maintenance, energy/demand management system, marketing and information and communication technology, and (vii) more secure from attacks [1]. A clear picture of Smart Grids is required to enable all stakeholders in accelerating the development process.

Smart Grids is a convergence of power system technology, information technology, and communication technology. It is a very complex and large system – a system of system. A concept of Smart Grids has firstly emerged in a practitioner arena and then in an academic area. The concept has developed from a rudimentary stage to an application stage. The development of Smart Grids illustrates the interaction between knowledge creation and knowledge application. Practical knowledge related to Smart Grids is created, demonstrated, improved, and implemented. The knowledge development of Smart Grids is in an interactive and iterative process.

Transformation from traditional electrical power system to Smart Grids has taken place for a number of years. It is involved with several stakeholders. It needs continuity and collaboration. The development of Smart Grids requires a series of actions. A series of continuous actions will be carried out in both near and far future. The roadmap is required to successfully move from a current status of electrical power system to a future status of Smart Grids.

Roadmap

A roadmap may refer to (i) a map showing roads especially for automobile travel; and (ii) a detailed plan to guide progress toward a goal, or a detailed explanation [2]. In this paper, the roadmap is used as a detailed plan. It is a document that shows an environment covers a period of future time, vision and objectives to be achieved in that environment, paths and directions to vision and objectives. Paths and directions make the roadmap different from other type of plan. Being the detailed plan, the roadmap serves as a tool that provides essential understanding, orientation, context, direction, and some degree of consensus in planning developments and implementations.

Roadmaps can comprise statements of theories and trends, the formulation of models, identification of linkages among and within sciences, identification of discontinuities and knowledge voids, and interpretation of investigations and experiments. Roadmaps can also include the identification of instruments needed to solve problems, as well as graphs, charts, and showstoppers. [3] In a roadmap, useful contents are summarized as follows:

- the present state, the future desired state, and the gap between what exists and what is needed;
- the highest potential areas and risky and unproductive areas of development in a specific period of time;
- critical enabling organizational capabilities that will be needed to move from the present state toward the future desired state;
- investment information for a purpose of decision making;
- a framework of coordination and leveraging
costs and benefits among stakeholders;
- a way to form collaboration and partnerships among stakeholders through the sharing of knowledge;
- a way to establish the development consensus and action steps needed to make the future desired state happen.

The roadmap is an output of a planning step toward ensuring the future desired state.

The roadmap is required for complicated and time-consuming activities of development, for example technology roadmap, product roadmap, and social movement of peace roadmap. The roadmap may be a short-term plan, a long-term plan, or both. The short-term plan becomes the roadmap if it consists of complex works and procedures and it shows path of development from a present status to a future desired status. The long-term plan, as the roadmap, has to express paths and directions moving from a present status through an immediate status and ending at the future desired status – the vision.

**Research Objective and Methodology**

The aim of this research is to describe a process of roadmap development – roadmapping. The roadmap is determined. Steps in a process of roadmap development will be stated. Roadmapping the Smart Grids of Provincial Electricity Authority (PEA) will be demonstrated as a preliminary study case. To achieve this, a qualitative review of literature and fundamental bases with respect to roadmapping is carried out. The study case shows a description of a series of activities of roadmapping the PEA Smart Grids. It presents an initial outcome, not the complete roadmap. The roadmap will be produced in the next step of a series of this research.

2. **ROADMAPPING**

**Foundation**

Roadmapping is a method of roadmap development process. It is a way of imaging and expecting a series of future pictures at different points of time. It is a planning process of roadmap creation. It provides the mechanisms involved in creating a roadmap [3]. It is a way to identify organizational needs, map them onto desired organizational capabilities, and develop detailed action plans to ensure the required organizational capabilities will be available when needed. The organizational capabilities are a set of ability of organizational processes to do activities. Activities refer to what an organization does. Doing activities is aimed at pursuing three main generic objectives of the organization – (i) to perform routines, (ii) to respond to changes or to perform routines better, and (iii) to transform parts of the organization or the whole organization to a new paradigm e.g. new business areas, new market structure, new products, and new technology process. Roadmapping results in a roadmap. In other words, the roadmap is an output of a roadmapping process.

Roadmapping is a planning method in a long-term planning cycle. It differs from other planning and analysis methods in several aspects. Firstly, it is driven by requirements of customers, rather than advancement of technology. Secondly, it further advances on a vision and objectives, and organizational capabilities. Thirdly, it provides a route for achieving the vision and objectives, going from today to tomorrow, by helping organizations identify, select and develop all necessary organizational capabilities needed to produce the outcome and impacts for future environments. In addition, roadmapping provides both a wider scope and continuity of development. For example, roadmapping is applied to product portfolio, rather than single product, or several periods of time, rather than a single period of time.

Practitioners in both public and private sectors have applied roadmapping for their different purposes for decades. For example, the technology roadmapping initiative was launched by Industry Canada in 1995 as part of its strategic plan to support Canadian innovation. Applications of roadmapping are for example, (i) forecasting a technological future trend, a market future trend, a product future trend, and (ii) visualizing the relationships between markets, products, and technologies over time. Roadmapping helps to link technology, market and product to business needs. Roadmapping has a great potential to be applied in many different contexts because it has inherent flexibility in terms of architectural structure and process.

Academicians have used roadmapping as one of the methods in the strategic management. Apart from an academic field of strategic management, roadmapping is related to change management, operation management, technology management, and organizational learning. These academic fields provide the theoretical foundation to the roadmapping knowledge development. Specific bodies of knowledge are, for example, phase of change (i.e. preparation, implementation, and sustentation), action plan, technology assessment, technology acquisition, technology innovation, learning curve, knowledge sharing, and capabilities development by organizational learning.

The common roadmapping knowledge is proposed in terms of “know-why” of definition and strategy; “know-what” of direction; “know-how” of technology; “know-when” of action plan and investment strategy [1]. The theoretical and practicable roadmapping knowledge in both practical and academic areas needs to be further concurrently developed.

**Classification**

Roadmapping can be classified into various groups of type based on different perspectives. For example, from a perspective of managerial functional purposes, roadmapping can be classified into roadmapping of forecasting, planning, and administration. From a perspective of units of roadmapping, it can be classified into roadmapping of technology and product. From a perspective of roadmapping boundaries, it can be classified into internal and external roadmapping. Internal and external roadmapping reflects sources of information and data analysis. From a perspective of time frame, it can be classified into short-term and long-
term roadmapping. The time frame is a scope of time covered in roadmap as horizon of mapping. Roadmapping will reveal both a static view (e.g. status, portfolio, and position) and a dynamic view (e.g. plan, and trend).

**Process**

Some parts of a strategic management process are adapted to set up a roadmapping process. Three are six steps of roadmapping as follows:

1. identifying trends and directions of development;
2. forming a shared vision;
3. evaluating gaps between current positions and vision;
4. identifying product and service functional operation and strategies;
5. identifying critical organizational capabilities and means to develop and allocate such organizational capabilities;
6. prioritizing and timing designed actions; and
7. creating a roadmap.

Some steps may be repeated. Tasks in each step, especially step 6, will lead to useful information in a roadmap, including description of a present state, a future desired state, vision, objectives, potential and unproductive areas, framework of coordination and leveraging, collaboration and partnership, investment information, consensus of development, and priority action plan.

A team leader and working groups will be acquired and established. Members of the working groups are a combination of cross-functional work units and multiple disciplines. The established working groups will carry out the abovementioned tasks.

A roadmapping process can start with: (i) the needs of market and customers (a market-pull perspective); or (ii) the innovative technologies (a technology-push perspective) [4].

**Value of Produced Roadmap**

An end of the roadmapping process is a roadmap. The produced roadmap is valuable if it is needed by stakeholders, important for development, feasible, and has significant impacts.

A roadmap responds to requirements of customers and other stakeholders. Resource allocation reflects the requirements.

A roadmap consists of requirements, recommendation, priority action plan, and investment information. It is important for investors and developer. The investors and developers are the key roadmap users.

A roadmap expresses a technically-, financially-feasible work plan. Such workable plan is realistic and can be implemented within a limited time and resources.

A roadmap has its two groups of impact. A roadmap itself provides a stimulus to the development. The stimulated development can be product, technology, organization, industry, sector and country. Results of roadmap implementation are another group of impact. They are expected to contribute to the targeted organizations, industry, society and a whole country.

### 3. ROADMAPPING THE PEA SMART GRIDS

Provincial Electricity Authority (PEA) has engaged in the development of Smart Grids. Smart Grids is the future of electric power system and electricity supply businesses.

**Developing the PEA Smart Grids**

The PEA Smart Grids will be developed on the bases of (i) needs of customers who are both producer and consumer of electricity, (ii) integration of thousands distributed generations, (iii) bulk power and small scale sustainability coexistence, (iv) demand and supply balance solutions, and (v) demands for efficient operated and reliable electrical power system [5].

The PEA Smart Grids development is based on the conception of vision, target, strategy, implementation and operation, professional, and critical success factors [6].

PEA has realized the critical needs for Smart Grids development. The Smart Grids development working group was appointed by the Governor, a PEA leader. A deputy governor was appointed to be a chairman of the working group and an assistant governor was appointed to be a vice chairman.

Stakeholders of Smart Grids were identified and their roles were described [6].

![Fig. 1. Stakeholders of PEA Smart Grids](image-url)
critical technical success factor is an organization-wide information management. The critical managerial success factor is organizational capabilities to change. Change toward Smart Grids refers to, for example, technology adoption, reorganizing, restructuring, reprocessing, re-staffing. Change management is related to all attributes of organization (i.e., strategies, people, technologies, resources, structure, process, learning and culture) and environments of the organization. Four critical success factors in Table 1 are characteristics of these two domains of technological and managerial critical success factors. Four stage of Smart Grids development are a definition stage, a preparation stage, an implementation stage, and a sustentation stage.

Table 1. Conception of PEA Smart Grids

<table>
<thead>
<tr>
<th>Conception</th>
<th>What is</th>
<th>What is NOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vision</td>
<td>(1) Electricity Users First (2) PEA Employees</td>
<td>(1) Technology-Driven (2) Supplier-Driven</td>
</tr>
<tr>
<td>Target</td>
<td>Sharing : Data, Information, Resources</td>
<td>Stand Alone, Selfish, Blocking, Fence, Enclosure, Slow, Sluggish,</td>
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<tr>
<td></td>
<td>Speed : Service, Response, Simplicity, Active, Proactive</td>
<td>Susceptibility, Vulnerability</td>
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<td></td>
<td>Security : Physical, Cyber, Optimal Redundancy</td>
<td>Strictness, Stiffness, Rigidity</td>
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<td></td>
<td>Suppleness : Flexibility, Elasticity</td>
<td>Redundancy, Overlap, Expensive, High Cost</td>
</tr>
<tr>
<td></td>
<td>Saving : Low Cost, Cutback, Cost Reduction</td>
<td>Hazard, High Risk</td>
</tr>
<tr>
<td></td>
<td>Safety : Equipment, Operator and Public Safety</td>
<td></td>
</tr>
<tr>
<td>Strategy</td>
<td>Holistic Approach &amp; Entire Organization, Prioritization</td>
<td>Single Function, Single Work Process, Do all at one time</td>
</tr>
<tr>
<td>Implementation &amp; Operation</td>
<td>Cross-Functional Working, Multiple Work Processes, Shared Data &amp; Cooperative Applications</td>
<td>Only one Group, Only one Team, Only one Working Unit, Only one Work Process</td>
</tr>
<tr>
<td>Professional</td>
<td>Inter- and Multidiscipline, Power Engineering &amp; IT Engineering &amp; Communication Engineering</td>
<td>Only One Branch of Engineering, Only Engineering, Only Finance, Budget, HR, etc.</td>
</tr>
<tr>
<td>Critical Success Factors</td>
<td>Customers : (1) External Customer : Electricity Users (2) Internal Customer : PEA Employees</td>
<td>Technology-Driven, Supplier-Driven,</td>
</tr>
<tr>
<td></td>
<td>Collaboration : Data Integration, Work Process Integration, Resource Sharing, Organization-Wide Data Management, Synergy, Interoperability</td>
<td>Separation, Division,</td>
</tr>
<tr>
<td></td>
<td>Communication : (1) Communication Infrastructure (2) Organization Communication, Team Communication</td>
<td>Stand Alone, On Bookshelf, In Library</td>
</tr>
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<td></td>
<td>Continuity : Sustainability, Policy, Organization Vision, Shared Vision, Commitment, Next Generation of SG Teams</td>
<td>Individual Personal Initiatives, One Man Show, Fad, Imaginary Tale</td>
</tr>
</tbody>
</table>

Needs for Roadmapping

PEA has investigated, evaluated, assessed, and identified a current state, formed a preliminary framework, and established a Smart Grids working group. To move forward the Smart Grids, PEA needs to create a Smart Grids roadmap because of:

- additional requirements of customers and stakeholders;
- new landscape of Thailand electricity supply industry;
- entering new markets of a PEA ENCOM International company, a PEA subsidiary;
- seeking out new Smart Grids technologies;
- acquiring new technological and managerial skills;
- facing a future competitive threat;
- needs for a shared vision of PEA Smart Grids and strategies for making that vision reality;
- needs for knowledge (i.e. know-why, know-what, know-how and know-when) to handle with uncertainty about Smart Grids technologies and their applications;
- needs for consensus within the Thailand electricity supply industry on the feasible technology choices for future development;
- needs for joint efforts in R&D, innovation, sourcing, or supply-chain arrangements with
other stakeholder in the electricity supply industry.

Roadmapping the PEA Smart Grids

Roadmapping the Smart Grids is necessary for PEA for its smooth Smart Grids development. The roadmapping of PEA Smart Grids is aimed at forecasting requirements, planning activities and resources, and providing administration guidelines. It is the internal and external roadmapping. The internal roadmapping will lead to the priority action plans. The external roadmapping will result in understanding about the Smart Grids at the industry level and a country level. The roadmapping of PEA Smart Grids is both short-term roadmapping and long-term roadmapping. The time frame covers a 5-year period, a 10-year period, a 15-year period, and a 20-year period. In roadmapping the PEA Smart Grids, all seven steps of roadmapping process are narratively described.

Step 1: Trends and Directions of Development

It is observed in PEA, especially among top management, that Smart Grids is a generally accepted concept of PEA future development. Since 2007, Smart Grids has been a hot topic of wide discussions and several training courses for different hierarchical PEA staffs. At this beginning of development, the concept of Smart Grids is applied to not only an electrical power system, not also support work processes –for example power procurement and market operations. Smart Grids is positioned as a strategy of PEA organizational development. It is expected to broaden a scope of potential businesses.

Step 2: A Shared Vision

PEA will develop a shared vision statement describing the purposes and long-term goals of the Smart Grids roadmap. This vision statement expresses the desired future result based on a current position. Focus group discussion is one of ways to shape and bring out the shared vision. This step will take a lengthy time.

Step 3: Gaps between Current Positions and Vision

The evaluation of gaps between current positions and vision is needed in order to determine technical and managerial requirements and investment capital. It may lead to the upgrading of existing systems, the constructing of new systems, the acquiring of new human resource competencies, the establishing of new work units/processes, and the restructuring of organization. In determining the technical requirements, foreign consulting services are required.

Step 4: Functional Operation and Strategies

PEA needs standards of interoperability in order to (i) overcome difficulties of technology adoption, (ii) make different diverse technologies interoperable, and (iii) lower cost of interoperability establishment. PEA also needs functional operations and strategies to incorporate the information and communication technology into a traditional electrical power system and work processes. Technology choices will be assessed and selected.

Step 5 : Critical Organizational Capabilities

To develop Smart Grids, new organizational capabilities are needed. PEA will identify both new technological and managerial organizational capabilities. New organizational capabilities may result from the upgrading of existing organizational capabilities or the new acquisition. Choices of “build or buy” organizational capabilities must be made.

Step 6 : Actions

Actions of Smart Grids development are designed, prioritized, timed, and expressed them together as a plan. A priority action plan states tasks and their allocated resources in an order of their importance and time in operation. The priority action plan includes the prioritized actions of not only Smart Grids development, but also organizational capabilities acquisition.

Step 7: Roadmap

In creating the Smart Grids roadmap, PEA realizes that the roadmap is a mechanism enabling PEA to visualize its critical organizational capabilities (i.e. skills, technologies, competencies, and relevant resources) and critical actions required to achieve the objectives and reach the vision. The Smart Grid roadmap will display the interaction between technology and system development over time from both short-term and long-term aspects of development.

4. CONCLUSIONS

This paper shows the fundamental bases of roadmap and the process of roadmap creation, roadmapping. The roadmap is defined and characterized, especially by paths and direction toward vision. Foundation of theoretical and practicable knowledge, classification, process, and value of product of roadmapping are stated. Provincial Electricity Authority, the largest electricity distribution and service utility in Thailand, is a selected narrative case. Stakeholders of PEA Smart Grids are identified. Applying findings of roadmapping, PEA plans to develop its Smart Grids. All seven steps of roadmapping the PEA Smart Grids are summarized. After producing the roadmap of PEA Smart Grids in the next step of a series of this research, value of the roadmap will be evaluated in a planning phase.

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