THE CHALLENGES IN DEVELOPING A SMART GRID ROADMAP FOR THE DISTRIBUTION NETWORK OF IRAN

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ABSTRACT

The first step in planning for the smart grid implementation is to identify the present state of the grid and its infrastructure, the next step being to describe the vision. Thereafter is gap analysis. Gap Analysis is the method by which the road map is developed from where the grid is now to where the grid should be.

Every power grid has its own characteristics and the level of its advancement is one of the main criteria for deciding on how to plan the smart gird implementation. Naturally planning the smart grid implementation in Iran should be done in accordance with Iran's electric grid structure and potentials.

THE NECESSITIES OF DEVELOPING A ROADMAP FOR THE IMPLEMENTATION OF THE SMART GRID, AND RELATED METHODOLOGIES

Developing a road map is a comprehensive process applied for determining the investment and planning of the budget by way of describing the present situation, the desired future state (vision) and analyzing the gap between them in order to increase profit, fulfill customer requirements and the future needs of that system.

A Smart grid road map is defined as a set of subsystems and technologies which describe the different layers of the implementation, including equipment, communications, information, operations, and businesses for migration from present to future state, in different time periods. Several methodologies exist which could be used for the development of a road map by different organizations depending on their needs and circumstances. Some of these methodologies are as follows: SWOT analysis, benefit/cost analysis, value chain analysis, PEST analysis and so on. Based on the research done and the statistical data derived from interviews with managers of strategic planning projects, the tendency to use methods with simpler techniques such as SWOT and PEST is higher than more complicated ones [1].

Obviously, each of these methodologies has their own advantages, which organizations should choose based on these advantages and whether it is appropriate for their structure and project organizations.

THE SMART GRID ROADMAP OF THE COUNTRIES OF THE WORLD

In this paper, the smart grid road maps of different countries and their goals are examined [2]… [12].

Selection criteria for the target countries are their high investments in smart grid technologies, the existence of a roadmap, their having a leading role in related research and standardization, their large scale smart grid implementation projects and the accessibility to their information. Table 1 shows the different phases of the smart grid roadmap in these countries.

As one can see phase 1 generally encompasses planning, pilot projects and infrastructure development. In phase 2 standard developments as well as the participation of customers are carried out. In phase 3 the migration to a smart grid is gradually completed.

Table 1- Smart Grid roadmap in sample countries

	Phase1	Phase2	Phase3
Japan [2]	Technology development of renewable energies and grid-connected system development	Technology demonstration in real environment "Smart Community"	
China [3]	Planning, pilot projects and standard development	Roll-out construction	System improvements
Australia [4]	Foundations to monitor and manage data across the network business	Analytics to improve business decisions and operations	Enabling technology to automate functions
South Korea [5]	Smart Pilot City	Wide area extension of pilot project (consumer Intelligence)	National smart grid completion
U.S.A [6] (New York State)	Smart grid efforts on providing a solid smart grid foundation	Smart Grid-related technologies	
U.S.A [7] (South California Edison)	Foundation, Information Technology and Automation	Interactive (Grid 1.0 evolution to Grid 2.0)	Intuitive & Transactive grid
Canada [8] (Toronto Hydro)	Establish Toronto's Smart Community- demonstration projects	Expansion of demonstrated initiatives- pilot projects results	Complete integration of technologies and services- collaboration between the utility and customers

THE ROAD MAPPING PROCESS FOR THE SMART GRID OF IRAN

In general, the road mapping process for smart grid development consists of five main stages. For any electric grid, each stage includes activities exclusively related to that particular grid. The steps taken and the results obtained from studying the development of a roadmap for Iran's grid are as follows:

Stage one: current state identification
The grid's infrastructure and its potentials in connection to the criteria below are identified:

- existing operation features
- key economic and business processes
- key technologies
- human and financial resources
- economical, social, cultural, international, and environmental policies
- routine and engineering activities

Stage two: technology assessment
States of the key technologies associated with the smart grid are evaluated:

- evaluation and identification of weaknesses, challenges, strengths and opportunities associated with smart grid
- reviewing smart grid roadmap development projects in the world
- considering development plans of suppliers and manufacturers
- reviewing international standards and their compatibility

Stage three: outlining the vision
Using results obtained in stages 1 and 2, the vision of the smart grid is pictured:

- identification of motivations and business drives for smart grid development
- description of enabling technologies for the future smart grid
- description of future targets

Based on the studies of the electric grid of Iran and the roadmap of several countries (companies) worldwide, the prospects of a smart grid in Iran are summarized as the following four categories:

- Increased network security and reliability through automation systems with self healing properties
- Customer participation in both production and consumption of electrical energy
- Increasing generation by raising the use of renewable sources and distributed generation
- reducing greenhouse gas emissions

Stage four: technology gap analysis
Gap analysis is carried out in order to determine technical, managerial, and major investment requirements for corporate restructuring, updating current systems and establishing new processes:

- reviewing process and technology gaps
- evaluation of economical issues
- technology classification
- feasibility of technology implementation

Stage five: component identification and roadmap development
Roadmap development is a mechanism by which key features of organizational capabilities (i.e. skills, technologies, competencies and related resources) and activities required to achieve the objectives and fulfill the vision is provided. Taking into account the studies done, including the world's experiences, the potentials of the grid and the existing infrastructure, Iran's smart grid roadmap should be developed by:

- specifying challenges, strategies, policies and development plans
- classifying related technologies and prioritizing development plans
- specifying deployment and development requirements of technology
- specifying business needs
- specifying organizational changes
- planning for research, pilot projects and infrastructure development

Iran's smart distribution network's technical and non technical challenges

Smart grid's model developed by NIST (National Institute of Standards and Technology), comprises of seven domains: bulk generation, transmission, distribution, customers, service provider, operation and market[13]. In mapping Iran's power grid structure to the conceptual model introduced by NIST, two of the defined domains are intermixed, and the resulting domains for Iran's grid are as follows:

1. bulk generation
2. transmission
3. distribution(combination of distribution, service provider and distribution operation)
4. customers
5. grid management and market (combination of transmission , generation and market supervisory)

Fig.1 shows the Iran's smart grid domains and their entities. Identifying technical and non technical challenges in each domain is essential for developing the roadmap:

Bulk Generation domain
Technical challenges are as follows:

- aging power plants and automation problems
- providing precise dynamic generations and an economical model for exact market pricing
- forecasting problems of renewable generation units
- need for communication infrastructure
- requirement of high level reliability in power plant control systems
- standards development related to participation of generation companies in market

Nontechnical challenges are as follows:

- vast investment in control and monitoring system, communication network, control center changes of old power plants

Transmission domain

Technical challenges are as follows:

- importance of reliable high speed data exchange in the transmission system
- need for synchronized wide area protection with controllable devices like PMUs
- common information model standardization for data exchange and interoperability
- cyber security importance

Non technical challenges are as follows:

- need for vast investment in controllable devices

Distribution domain

Technical challenges are as follows:

- replacing manual controllable devices with automatic ones
- need to provide common information model standards for data exchange and interoperability
- establishing distribution control systems (automation)
- establishing control and operation centres (SCADA)
- change of protection strategies because of bidirectional flow of energy in presence of DERs
- cyber security
- uncertain load and generation forecast for renewable microgrids and their balance control problem

Non technical challenges are as follows:

- need for vast investment (communication infrastructure, controllable devices, visibility whole network)
- explain smart distribution benefits to decision makers and managers
- technology obsolescence
- quantifying impact of smart grid on distribution network
- regulation gaps in various smart distribution grid programs
- restructuring the distribution domain
- customer privacy issues

Customer domain

Technical challenges are as follows:

- standardization requirements(information model, smart appliances, trading electricity, electric vehicles and customer side distributed energy resources integration)
- home appliance controllability and their coordination with the building management system
- high speed communication network
- bidirectional metering devices
- demand side management/demand response programs (intelligent interactive appliances sensitive to price of electricity)

Non technical challenges are as follows:

- need for vast investment (metering devices)
- production of intelligent home appliances
- electric vehicles and smart transportation
- training courses on load management, home automation and efficient use of electric vehicles
- customer incentive programs

Grid Management and Market domain

Technical challenges are as follows:

- send, receive and process large amounts of data
- technical and economical common information model standardization
- cyber security
- efficient market clearing strategy and online pricing according to online grid data restrictions
- bus voltage and frequency stability
- precise load forecasting and generation balancing according to renewable and electric vehicle sources

Non technical challenges are as follows:

- efficient business roles, clearing transaction between generation units and grid management
- participation of small generation units as well as large ones in the market

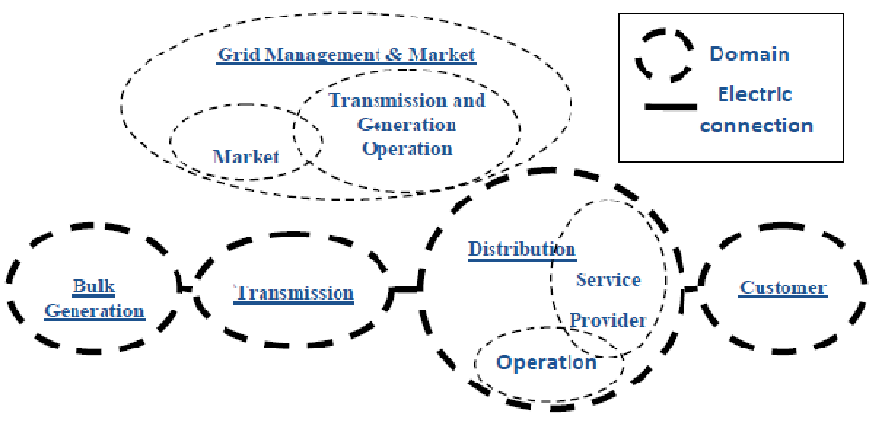

Fig1- Iran's electric Power domains

Based on the results of the conducted studies and the analysis of experiences of other countries, and taking into account the distribution network's potentials[14], planning for migration to smart grid for the distribution network of Iran is suggested in Table2.

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Table 2 –Distribution network smart grid Planning in Iran

Phase1	Phase2	Phase3
Conducting Research: Research on smart grid technologies **New Regulations:** Communication infrastructure, deregulation, energy management and customer participation, markets **Pilot Projects:** Use results for future developments	**Infrastructure:** Advanced metering infrastructure and two-way communication **Distribution Automation:** Advanced metering and control systems in distribution network, energy management system **Pilot Projects** Renewable energy, distributed generation, energy storage, electric vehicle **Standards** Interoperability	**Smart Metering** Smart metering for all customers **Customer** Participation of customers in demand response programs and market **Electric Vehicle** Use of electric vehicles **Smart home** Installation of smart devices in homes **Renewable energy and distributed generation** Use of renewable energy, distributed generation and energy storage devices **Network Automation** Distribution automation and self-healing