Actionable Strategies

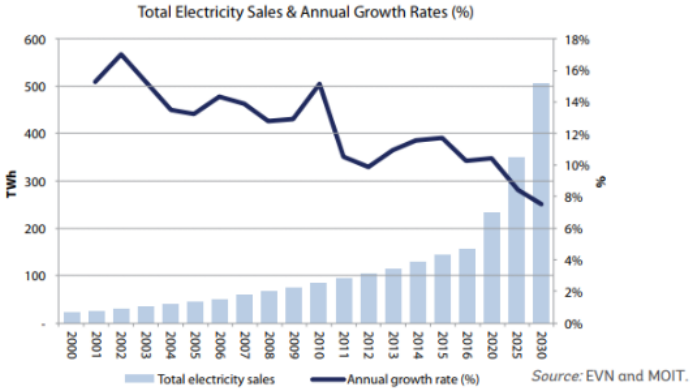
Case Study: Smart Grid Strategy and Roadmap

Client Profile

The Central Power Corporation of Vietnam is a subsidiary of Vietnam Electricity (EVN), a state-owned enterprise. While primarily responsible for power transmission and distribution, CPC also operates hydropower generators. The headquarters is in Danang and regulated by the Electricity Regulatory Authority of Vietnam in Hanoi.

Power Market Overview

Vietnam has experienced rapid growth over the last decades with the attendant urbanization and industrialization. Electricity demand has increased even faster and successfully meeting demand has been a key driver of Vietnam's development. Supporting this demand has required significant investment in power sector infrastructure despite the lack of cost recovery due to government price controls.

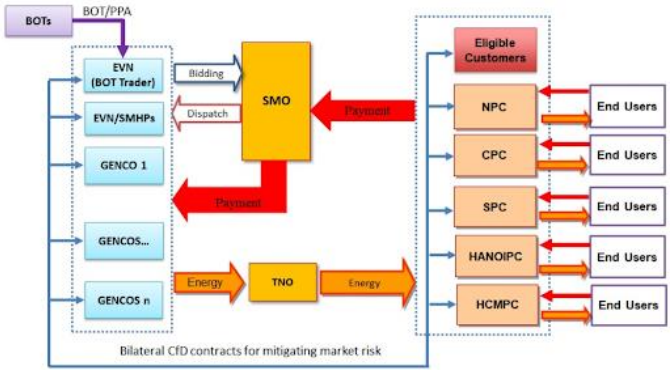


The Smart Grid strategy for Vietnam needed to include investments with positive ROI. The portfolio of initiatives will reduce the reliance on debt financing by closing the cost recovery gap. This further

supports market-oriented reforms in the Vietnamese power sector and specifically at CPC.

Free Market Reforms

Price controls will eventually be removed and the strategy needed to ensure a smooth transition to the Vietnam Wholesale Electricity Market. The structure and technology will evolve in maturity over several years. The strategy and any technical implementation projects needed to account for the eventual separation of the distribution company into smaller, functional organizations.



Eventually, there will be ring-fenced entities encompassing:

- Retail
- Distribution
- Meter Data Management Service Provider
- Generation

These entities operate independently but the processes must integrate from end-to-end to provide customers with a seamless experience. Implicit in this requirement is the need to share data across process and organizational boundaries while protecting other data that would provide unfair competitive advantages.

Project Objectives

When Actionable Strategies was awarded this Smart Grid project for Vietnam, the Chairman stated that CPCs motto was "Application of Information Technology in Operations Management, Production and Business". The IT Strategy and Enterprise Architecture for CPC's Smart Grid is targeted to:

- Reduce system losses
- Improve management
- Improve operational efficiency
- Improve the quality of supply and electricity services to customers

Situation Analysis

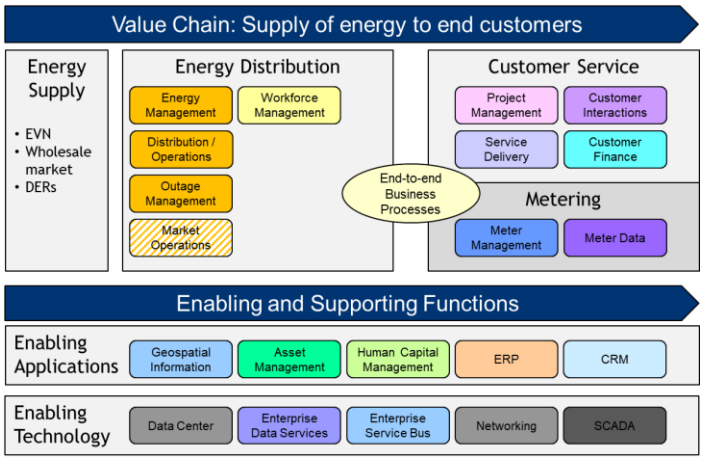
An organization-wide review was conducted to assess the situation and the readiness of CPC to execute strategic initiatives. Multiple dimensions were evaluated for the current and target analyses.

- Existing strategy and measurement systems including a Balanced Scorecard
- Business processes, automated and manual
- Financing

- Power distribution network
- Operational technologies
- Human capital
- Information and communications technologies

Business Blueprint

To facilitate strategic analysis and a top-down plan, a business blueprint was developed. The blueprint highlighted the core business functions and their interactions. This representation of the business then drove the Enterprise Architecture.



Business Processes

Operational processes had many manual sub-processes. The slowest processes with the most labor involved were in Outage Management and Workforce Management. These processes necessitated investments in both applications and integration of systems to create end-to-end processes. Automation of these frequently used processes will yield dramatic improvements in operational metrics and efficient use of human capital.

Power System Quality Metrics

CPC made great improvements in the broad range of power quality indices of MAIFI, SAIDI, SAIFI, CAIFI, CIII and ASAI. There were a number of further improvements that were targeted as part of the Smart Grid implementation.

- Load losses on feeders
- Frequency and duration of outages through Distribution Automation and an Advanced Distribution Management System
- Restoration time
- Frequency of equipment and system failures through an Asset Management System

Technology

Substation automation at CPC is world class. Distribution management is maturing but will benefit from ADMS applications added onto the foundation. There is no integration between OT and IT which is a major challenge.

CPC operates a data center and wide area network which were well-planned with mature operations. Customer management, human resources, finance and accounting, and project management systems were all hosted internally along with some ERP modules.

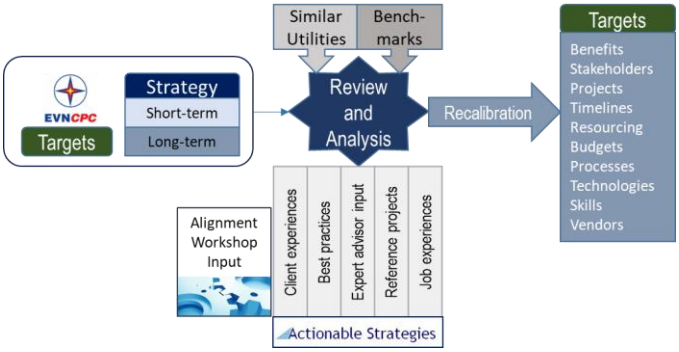
The fundamental challenges with IT systems arise from the organic and unplanned nature of their design and development. Each application was built for a single purpose, utilizing different technologies. There were no standards applied with any integration

being point-to-point, sharing only the data needed for that individual release of the application.

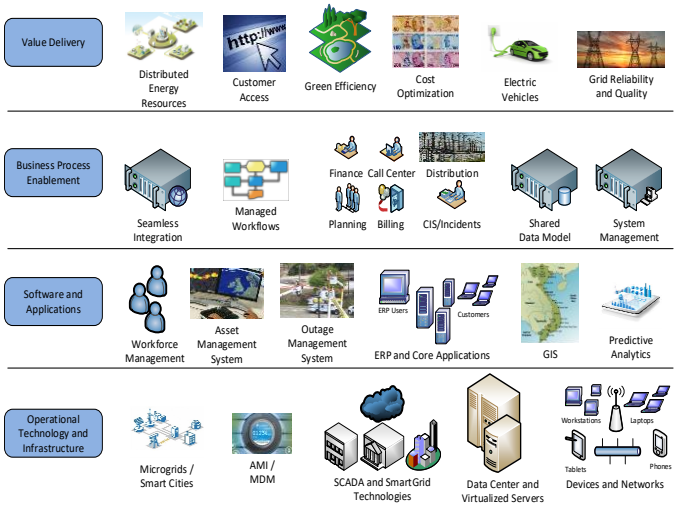
Pursuing an enterprise architecture requires an integration approach for both data and applications. In CPC's case, the most appropriate approaches were an Enterprise Service Bus and an IEC CIM-compliant data warehouse. Standards required refactoring of applications that were deemed durable and an integral part of operations. A methodology for assessing applications and the appropriate refactoring approach was provided to CPC.

Smart Grid Strategy

To formulate the Smart Grid Strategy, the following planning framework was used. It drew upon proven techniques from similar projects and was tailored to CPC's specific needs and situation.



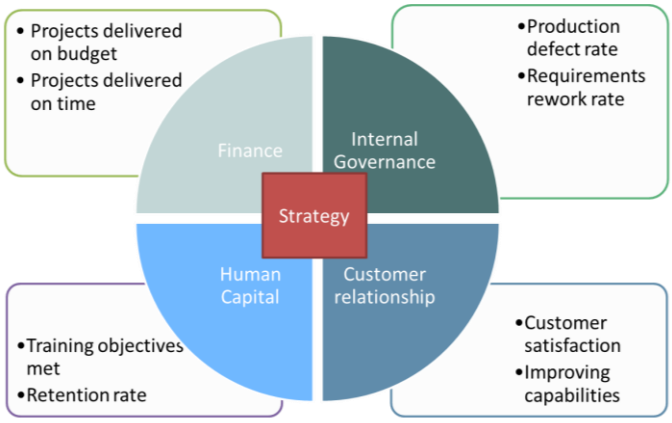
The resulting strategic plan was built top-down. Individual initiatives gave due consideration to bottom-up tactical goals and near-term constraints. The capabilities, enabling technologies and points of leverage for CPC were summarized into the following diagram.



Supporting layers beneath the value chains were evaluated for their ability to support strategic Smart Grid initiatives. Gaps and necessary investments were then incorporated into the implementation plans.

IT Balanced Scorecard

Information and communications technologies are key enablers to a Smart Grid. As part of the project, strategic goals for IT were created along with a measurement system. These measures had linkages to compensation to maximize alignment, support change and drive behavior.



The measurement system used a Balanced Scorecard which rolled up to CPC's corporate Balanced Scorecard.

Roadmap of Initiatives

The strategy for CPC is evolutionary. Based on a number of key factors at CPC, a series of Smart Grid Initiatives were laid out into a Roadmap to provide the most business value. After building a foundation, subsequent initiatives were delivered which also provided functionality required later in the Roadmap.

The following factors were considered.

- Market and regulatory structure
- CPC's distribution region and customer base
- Grid and operational current state
- IT, network, data, governance and human capital capabilities
- CPC processes and industry best practices

Foundation

Because of the organic evolution of CPC's technology portfolio, individual projects resulted in islands of systems that could not share data or interoperate. This creates the need for core foundational technologies to easily and cost effectively integrate multiple systems.

The ICT foundation included the following major elements.

- Data Warehouse – Including a customer master, basic reporting, data analytics, aggregates and replicas, and Extract Transform and Load tools
- CIM – IEC 61970-3011 Common Information Model with IEC 61968-112 and 62325-3013 extensions
- ESB – An enterprise service bus incorporated into a resilient architecture
- GIS – Geographic Information System

Operational Improvements

CPC is a distribution company that buys the majority of its electricity from EVN at an agreed upon price. Technical losses between the point of common coupling with EVN and CPC's customers can be as large as 7%. In order to maximize revenue, it is imperative to eliminate as many losses on the network as possible through ADMS applications.

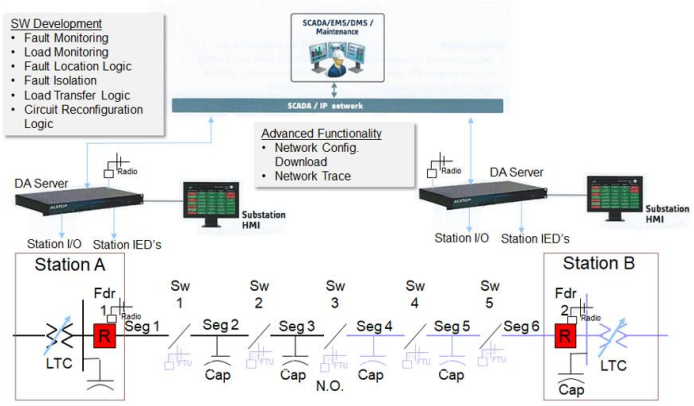
- Volt/VAR Management
- Conservation Voltage Reduction
- Voltage Flattening

Network Reliability

The goal of deploying Distribution Automation (DA) is to reduce the number of customers impacted by a fault on the network and the duration of any outage

caused by the fault. The planned DA system is made up of these core components:

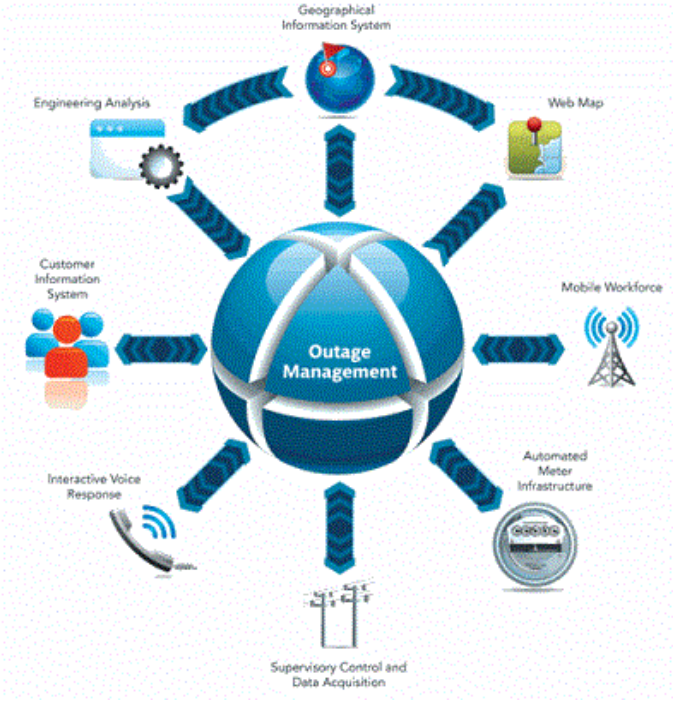
1. Motorized Sectionalizing Switches
2. Field Terminal Unit (FTU) data acquisition interface to motorized switch
3. Communication Network connecting the FTU's/Motorized Sectionalizing Switches
4. A SCADA master communicating to the FTU's
5. Industry protocol allowing communications between SCADA and FTU's



Customer Care

Using the foundation established for data sharing and integration, a complete Outage Management System was defined. Outages can be logged from any touchpoint. The Smart Grid Strategy identified the following sources:

- Customer calls including IVR input and call center interaction
- Web and mobile application
- Twitter
- Meter Data Management System
- ADMS/SCADA



Integration of SCADA/ADMS, OMS, GIS and MDMS provides detailed information about single or multiple customer outages. There are many use cases where the customer experience is improved.

1. Outages are reported in seconds from meter outage data through the MDMS and SCADA system. Operators can begin to mobilize crews immediately.
2. OMS operators now have much more data than previous random calls from customers to help them understand the severity of the outage and possible causes.
3. Meter data, SCADA data, and customer call in information data can be analyzed rapidly to find the root cause of the fault.
4. Switching orders can be immediately dispatched to the SCADA/ADMS operators to isolate the fault and restore power to all other customers on the feeder.

5. Crews can be dispatched to exact locations, given optimal routes to the location, and suggested spare parts to repair the fault.

Asset Management

Aging assets and rising maintenance costs are a drag on power utilities. Deploying a modern Asset Management System provides a number of opportunities for efficiency.

- Process automation including data acquisition and analytics
- Advanced analytics on monitoring and analysis data to move to just-in-time maintenance

Workforce Management

As a distribution company, CPC depends on a mobile workforce to operate the network. The workforce provides planned services throughout the lifecycle of a customer relationship as well as unplanned services in response to events such as outages.

Deploying a modern Workforce Management System requires integration with OMS, ADMS/SCADA, HRMS and GIS. This integrated WFMS will allow CPC to run a highly efficient operation with optimized costs and service delivery times. Crews must be equipped with mobile devices that communicate over a wireless network.

This includes the following operational sub-processes.

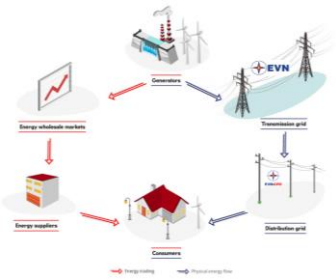
- Work order prioritization and management
- Crew assignment, parts assignment and service call routing
- End-to-end process management
- Data analytics to drive skills management and training
- Pre-emptive response utilizing weather and other situational data

Future Strategies

CPC and parent company EVN are both considering the future. Aspirations include incorporating Industrial Revolution 4.0 technologies. Our long-term strategy provides the ability to implement future strategic initiatives without being constrained by technology, process or human capital.

Our strategy and technical work assumed the following initiatives would be pursued in the near future as EVN and CPC embraced the potential gains from these opportunities.

Wholesale Market



The initial planning for a wholesale market in Vietnam is rudimentary but the market will grow in sophistication as market participants gain experience. Strategic planning assumed reduced periodicity to intraday load forecasting. Real-time situation awareness was therefore a technical assumption along with data analytics support.

Support for predictive models incorporating external data such as weather was a planning consideration.

Distributed and Renewable Energy

Distributed Energy Resources were not part of CPC's power system design. However, this will become a requirement and DERs will be introduced requiring the two-way flow of power. In addition, the generation mix will shift with a growth in renewable sources. This will require further automation of distribution network devices to maintain voltage profiles, avoid thermal overloads and prevent network instability.

MicroGrids

Microgrid use cases are growing in Commercial and Industrial and other campus settings. CPC's Smart Grid will be able to support current and anticipated microgrid deployments.

Electric Vehicle Management

Electric Vehicles place a significant burden on distribution grids which were not designed to handle EV loads. Overloading becomes more acute in many instances because charging frequently occurs during peak load times. Intelligent management of EV charging requires integration between customer touchpoints, EVs themselves, analytics on the power grid and situational awareness.

Smart Homes

Similarly, Smart Homes require a number of interfaces all supported over a robust communications network. Providing transparency to homeowners for time-of-use pricing and demand response events are two typical use cases. In addition, connectivity to home automation to enable cost optimization is a current expectation which will see an increase in demand as Smart Home Controllers and Smart Thermostats are more broadly deployed.

Energy Storage

Energy storage will become a more commonplace component of a distribution grid and endpoints as battery technologies advance. The cost, effectiveness and usefulness of energy storage will continue to improve. As adoption ramps up, CPC will require operational interfaces between SCADA/ADMS and storage devices to know when storage is being used as a source of electricity, control the amount of storage used, and to determine optimal charging periods.

Business Benefits

All initiatives contained projects that each contributed positive ROI. The overall Smart Grid Strategy has a positive ROI, meaning the initial investments in the

foundation were paid for by implementing the Roadmap.

The anticipated benefits included:

Operational Improvements

Load losses can be reduced by 3 to 5 % on well designed and maintained feeders. On longer feeders or feeders poorly designed or maintained loss reductions in the range of 5 to 7% can be achieved.

Once CPC moves to a Wholesale Market, penalties due to overages can be avoided using CVR.

CVR can also be used to defer large capital programs such as transformer replacement.

Network Reliability

By improving network reliability, CPC will improve customer satisfaction. While this is an intangible benefit it is absolutely critical to a public utility.

The primary tangible benefit is reduction of lost revenue due to power outages. Secondly, exact fault locations can be determined, and repair crews can be dispatched to exact geographic locations, reducing travel time and time to find the fault. Outage durations are greatly reduced, again reducing lost revenue.

Customer Care

Outages are a highly visible customer touchpoint for power utilities. An integrated Outage Management System provides numerous benefits for customers from individuals to the largest commercial and industrial companies.

Fault Location and Analysis

An integrated OMS provides detailed information for customers. By providing an estimated service time and repair time, customers receive the transparency they desire. Integration across multiple touchpoints including phone, Web and social media provides information to customers when they want it and in the form they want it.

Workforce and Repair Optimization

Integration of the OMS to the Work Force Management System enables CPC to optimize crews. Understanding the need for skills in addition to the parts required optimizes repairs. This results in reduced restoration time and obviates the need for return visits to obtain parts.

Service Restoration

Integrating the OMS to ADMS/SCADA further improves the restoration of service. By automating fault location to a section of a feeder, service restoration to operational sections can be provided to customers.

Proactive Power Quality Management

Detailed data can be gathered from an integrated OMS. This allows CPC to focus capital and maintenance programs based on detail information gathered from Power Quality Indices data from the OMS.

Asset Management

Deploying an Asset Management System can yield measurable benefits that recur over decades. This includes the potential to reduce 75% of load tap changer maintenance costs and deferment of major capital by extending the useful life of expensive assets such as transformers.

Workforce Management

Benefits were projected based on the following workstreams and activities.

1. Rapid issuance of work orders for both planned and unplanned outages
2. Optimal selection of crew based on skills and equipment needed
3. Spare parts requirements based on outage analysis before truck roll
4. Optimal routing of crews to work location
5. Repair procedures and equipment manuals available on mobile devices
6. Reduced repair and outage times
7. Reduced planned outage times
8. Remote update of as-built drawings and installed equipment

Future Benefits

CPC is now well positioned to become a world class utility, with a clear path to introducing modern technologies in a well-defined manner that maximizes gains while minimizing cost and risk.