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WHITE PAPER

Cloud Adoption in Electricity Transmission Utilities

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INTRODUCTION

Power utilities are the backbone of country's infrastructure that fuel economic progress in all domains. With changing dynamics including regulations, disruptive technologies and consumer expectations, utilities are evolving continuously to cater to these dynamics, and are placing emphasis in customer engagement, information technology (IT) transformation, operational technology (OT) and work and asset value management. While power generation utilities focus on meeting the supply commitments and distribution utilities strive to provide uninterrupted power supply to end consumers, electricity transmission utilities provide the infrastructure required to deliver electricity from generation sources to distribution utilities.

Objective of this paper is to give an overview of the areas that cloud based services can support electricity transmission utilities in achieving business priorities and key performance indicators.

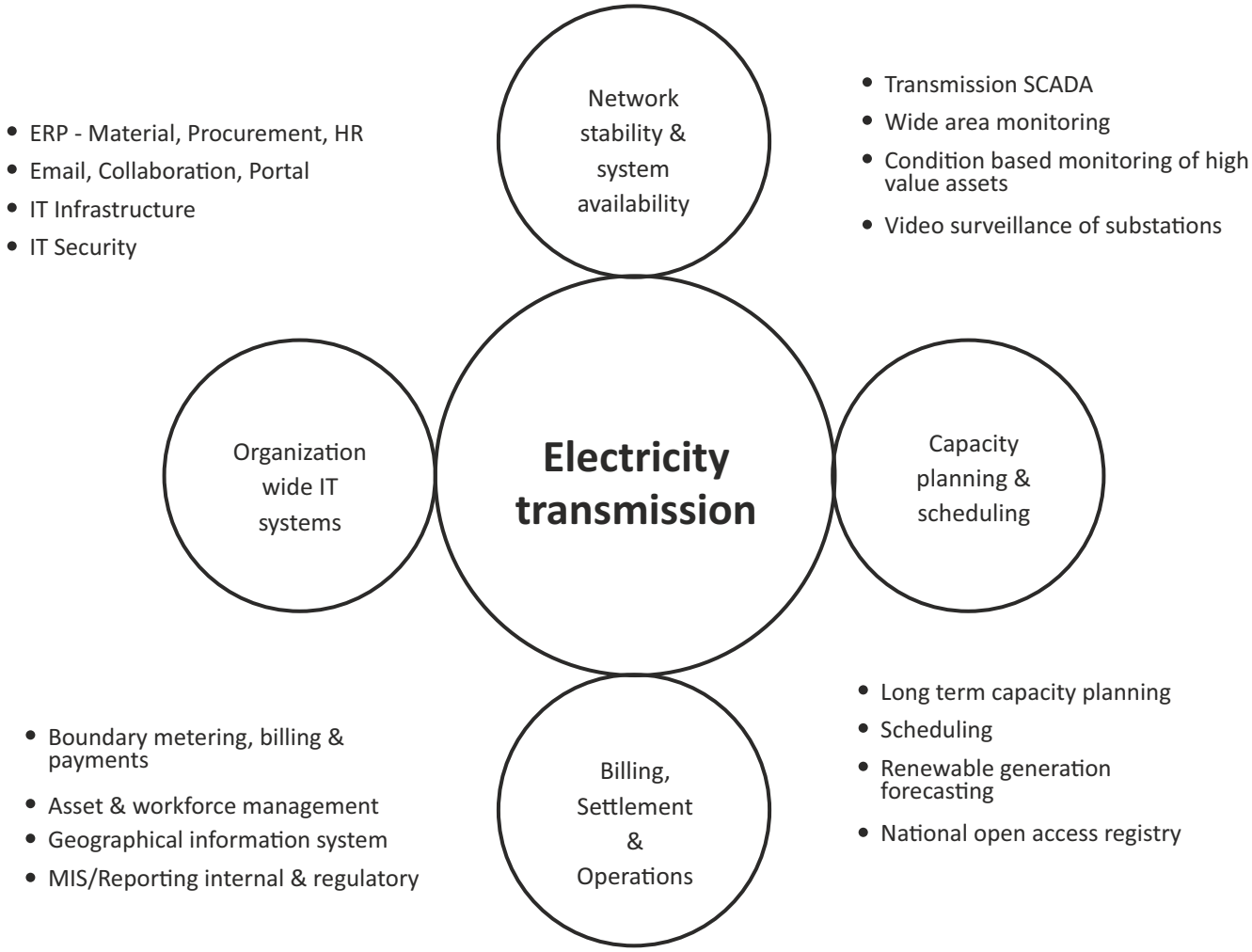
Business priorities of electricity transmission utilities in India

The business priorities of electricity transmission utilities in India can broadly be categorized into following areas:

- Constant monitoring and ensuring **Transmission Network Stability and System Availability**
- **Capacity Planning** of transmission network corridor and assets in order to cater to the increasing consumption
- **Scheduling** of energy transfer in transmission network corridor at national, regional and state level in optimum way so as to ensure system stability, and at the same time accounting for contingencies
- **Billing and Settlement** with distribution and generation utilities
- **Integration of Renewable Sources and Electric Vehicles** with respect to forecasting the potential capacity integration into the grid
- Leverage **Frontier Technologies** for efficiency improvement in the areas of transmission network management
- Analyze, identify and act for **Reduction in Network Losses**
- **Optimized Asset Utilization** and management by means of effective monitoring of asset condition, loading and capacity addition

In order to meet the required performance levels in these priority areas, electricity transmission utilities implement IT and OT solutions which include devices in the field, communication network and solutions at enterprise layer.

The picture below gives an overview of these IT and OT solutions that transmission utilities implement.



BUSINESS DRIVERS FOR MIGRATING TO CLOUD

In the process of improving efficiency in operations, electricity transmission, the utilities are adopting various IT and OT systems, which sometimes are on-premise data centers and sometimes on Cloud. Given below are business drivers detailing the aspects which drive customers to adopt cloud:

Scalability: Applications have varied load requirements which experience spikes and dips in the capacity utilization of IT infrastructure which should be scalable enough to cater to these load requirements. In a traditional on-premise implementation, capacity/load requirement is estimated and infrastructure purchases for long term, and this assumption many a times is not accurate enough. Moving to cloud gives customers the option of defining scalability policies which enables the supporting compute resources to scale based on load. For example, there could be a sudden surge in events due to fault in an HV line which implies that the

applications should be scalable enough to handle this surge by automatically scaling the compute resources. Similarly, customers can start pilot projects with smaller compute requirements on cloud and later scale up to expand the project scope e.g. an IOT based asset monitoring project started with few hundred devices and subsequently scaled to cover thousands of devices few months or years later.

Trade Capital Expenses with Variable Expense: With pay as you go model when deploying applications on cloud, customers spend based on usage of cloud resources unlike a traditional on-premise data center based implementation where significant investment is made in real estate space, physical security of premise, electricity, cooling, servers, storage, network etc. For example, performance testing of applications is a general requirement. In cloud, compute resources can be provisioned only for the period of performance testing and later terminated. This way, customers have to pay only for the period of usage instead of invest capital expenditure on compute resources.

Safer in Cloud than on-Premises: In a cloud environment, customers will have control over where data is stored, who can access it, and what resources are being consuming at any given moment. Fine-grain identity and access controls combined with continuous monitoring for near real-time security information ensures that the right resources have the right access at all times, wherever the information is stored. The cloud environment also inherits global security standards based on third party validation for thousands of global security compliance requirements. Cloud gives services and solutions which can be leveraged by customers to define security posture, few of which are in areas of threat detection, configuration evaluation, network security, filtering malicious web traffic, encryption key management, investigation of potential security issues etc.

Increase Speed and Agility: In a cloud computing environment, new IT resources are only a click away, which means that organizations can reduce the time to make those resources available to developers from weeks to just minutes. This results in a dramatic increase in agility for the organization, since the cost and time it takes to experiment and develop is significantly lower. This also gives flexibility to utilities to plan implementation of new use cases in a phased manner without gaps caused due to resource availability limitations.

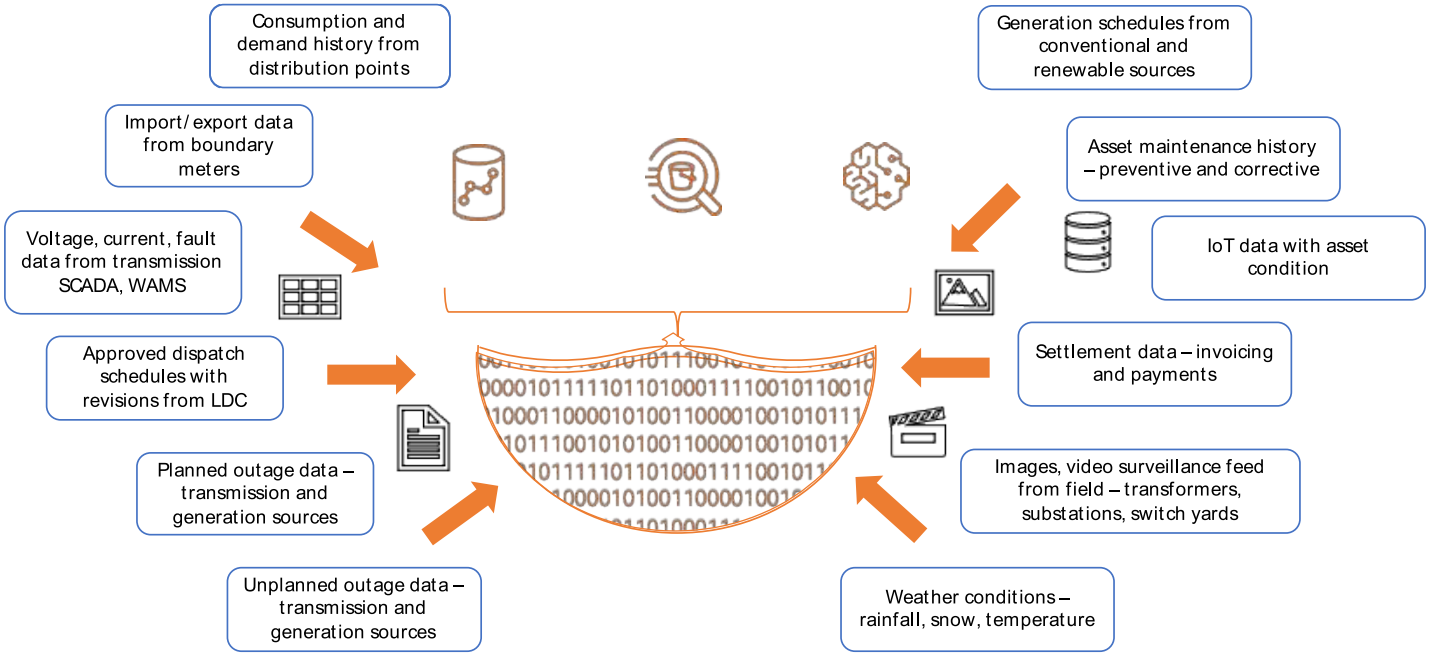
OPPORTUNITIES FOR CLOUD ADOPTION IN ELECTRICITY TRANSMISSION UTILITIES

Organizations can not afford to be slow and so prefer to move to cloud services which can provision infrastructure in minutes as against old world turnaround time of months. This new level of agility can help electricity transmission utilities also adopt cloud-based services to lower the turnaround time of their services to their end customers. There are areas where electricity transmission utilities can consider opportunities for cloud adoption. An overview of such opportunities is covered in following sections.

Common Utilities Data Lake for Central and State Transmission Utilities

Central and state transmission utilities have implemented systems to monitor the transmission network and also for management of operations. There is significant amount of data which is collected by these systems and this data lies within individual transmission utilities but could be useful for other transmission utilities as well. On premise data warehouse implementations typically hit road blocks in terms of storage capacities which leads to customers purging old data which could otherwise be valuable in analysis. Implementing a data lake in cloud gives flexibility to expand storage and compute to cater to large data sets which can be a mix of structured and unstructured data. Transmission utilities should implement state level data lake which can house data from multiple systems within the utility and this data lake can be used for basic reporting as well as advanced analytics spanning multiple departments' use cases and correlation analysis on data from multiple applications.

There can be more similar use cases that can be addressed by having a centralized data lake at national level which will hold subset of data from central and state transmission utilities, and accessible to all the utilities. Role based permissions can be defined to control access to data sets within the data lake. Utilities will have option to utilize additional analytics and reporting services using this centralized data lake as data source. For example, transmission corridor capacity utilization of a state transmission utility is a data set which can be used by central transmission utility to plan their network expansion. Similarly, the supply and demand schedules history from central transmission utility accessible to all state utilities can be useful data set for state transmission utilities to analyze and plan their activities.



IoT Based Asset Monitoring

Electricity transmission utilities are asset intensive and availability of these assets is important to avoid unplanned outages. Hence, monitoring of critical assets like transformers using IoT sensors for non-electrical parameters like temperature and oil levels, and generating alarms for threshold violations will help transmission utility operations to take preventive maintenance actions well in advance. Usage of open protocols like message queue telemetry transport (MQTT) or REST APIs and scalable IoT platform will enable transmission utilities have a unified platform for IoT based asset monitoring. Another important aspect to consider is the security layer in integrating with IoT devices which can include authentication using certificates for each IoT device, transport layer security, this data can be further used by utilities for advanced analytics using machine learning for predicting failures and for use cases like dissolved gas analysis.

Scheduling, Accounting, Metering and Settlement of Transactions in Electricity (SAMAST)

Electricity transmission utilities are implementing solutions for SAMAST framework for energy accounting and financial settlement. Utilities can implement cloud based advanced metering infrastructure solutions to receive meter data from interface meters which is an important data point for settlement. Similarly, the accounting and settlement solutions can be implemented on cloud instead of spending capital expenditure in implementing these solutions on premise data center. With implementation of these solutions on cloud, transmission utilities can have flexibility to integrate this data into utility wide data lake and run basic reporting as well as advanced analytics for use cases such as network losses analysis, corridor/line loading analysis etc.

Advanced Analytics

The vast amount data gathered from field devices such as including special energy meters, SCADA/EMSs, phasor measurement units (PMU) as well as energy flows(scheduled and actual), schedules and their revisions etc. can be used to run advanced analytics using machine learning (ML). Building a data lake on cloud gives the flexibility to use this data as source to machine learning algorithms for complex analysis and deriving insights from the data. There are various ML services and algorithms available on cloud which can be opted by utilities based on requirement and quickly start building and deploying analytical models. These ML services can take structured as well as unstructured data like images and videos from data lake and derive insights using built in algorithms such as linear regression, logistic regression, k-means clustering, principal component analysis, factorization machines, neural topic modeling, latent dirichlet allocation, gradient boosted trees, sequence2sequence, time series forecasting, word2vec, and image classification. The advanced analytics can be in the areas of planning as well as operations. In the context of planning, use cases can be for capacity planning for network expansion, demand and supply forecasting considering renewable generation integration and additional load added by electric vehicles into the grid. Similarly in the context of operations, use cases can be in the areas of analyzing data from high value assets to analyze asset condition, phasor measurement units data analysis. Cloud provides the environment required to run advanced analytics which typically demand higher performance processors and high speed networking infrastructure.

Computer Vision Based Asset Health Inspection

While there are IoT sensors which can be installed on critical assets and condition monitored, there can be more ways in which condition of assets can be assessed including computer vision. The source data required for computer vision based inspection can be static images, video feed from cameras at fixed locations or from drones. Electricity transmission utilities can apply these technologies to assess the health of critical assets. The use cases that can be applied in transmission utilities can be identification of fire in switchyards/ substations, corrosion in assets, movement detection in unmanned substations, aerial survey of HV/EHV transmission lines using drones etc. The image and video feed sources can publish data to the data lake and customers can choose cloud-based services for image analysis or video streaming analysis to analyze this data and derive insights. Cloud gives customers flexibility to expand the storage capacity as the volume increases unlike traditional on premise applications which hit a road block in terms of storage or compute capacity.

HOW TO MIGRATE TO CLOUD

Different customers choose different paths to migrate to cloud. While there are customers who were born in cloud, there are customers who moved their workloads from on premise data center to cloud.

Migration to cloud can be taken up as a three-phase process. While each phase is a common component of a successful migration, they are not discrete phases, but an iterative process. Multiple tools are available on cloud which can be leveraged by customers – such as migration evaluation, total cost of ownership calculator, architectural best practices, database migration services, hardware based data migration tools etc.

Assess: Assess the organization's current readiness for operating in the cloud. Most importantly, identify the desired business outcomes and develop the business case for migration. Once a business case is established, review the migration and modernization strategies, guides, and patterns to plan next steps.

Mobilize: Create a migration plan and refine the business case. The address gaps in the organization's readiness that were uncovered in the assess phase, with a focus on building a baseline environment (the “landing zone”), driving operational readiness, and developing cloud skills. To maximize the benefits of moving to the cloud, freedom and agility to innovate should be given to the teams, but also enforce controls to protect the organization from risk.

Migrate and Modernize: During the migrate and modernize phase, each application is designed, migrated, and validated. For many applications, the best approach is to rapidly move to cloud and then re-architect using cloud services. These cloud services can be used to quickly lift and shift (rehost) a large number of servers from physical, virtual, or cloud infrastructure to cloud.

In addition to migration of applications from on-premise to cloud or building application on cloud using cloud services, utilities can also opt for packaged solutions from cloud marketplace. Cloud solution providers maintain a digital catalog with thousands of software listings from categories like security, data and analytics and other areas for different industries. This reduces the time to implement and increases the speed and agility to move from idea to implementation.

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About India Smart Grid Forum

India Smart Grid Forum (ISGF) is a Public Private Partnership initiative of Ministry of Power (MoP), Government of India for accelerated development of smart grid technologies in the Indian power sector. Mandate of ISGF is to advise government on policies and programs for promotion of Smart Grids in India, work with national and international agencies in standards development and to help utilities, regulators and the industry in technology selection, training and capacity building.

ISGF work closely with government institutions such as CEA, CPRI, CERC, NSGM and NCIIPC; ministries such as MNRE, DoT, MoUD, MoHI etc and other stakeholders like state governments, electric utilities and electricity regulatory commissions. With 170+ members comprising of ministries, utilities, technology providers, academia and research, ISGF has evolve as a Think-Tank of global repute on Smart Grids and Smart Cities.

About Amazon Web Services

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