C. SCOPE OF WORK

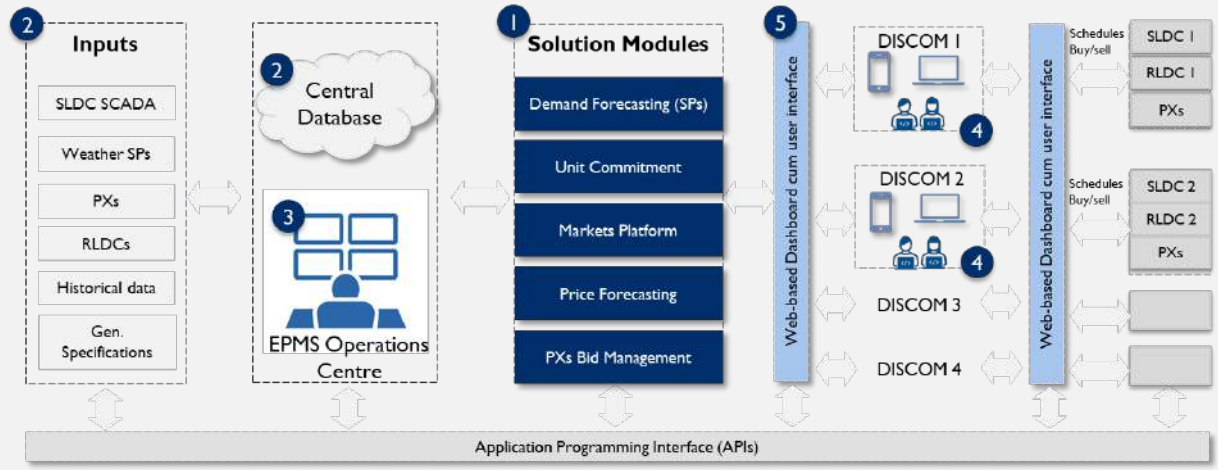
C.1. OVERALL ARCHITECTURE

The Central stakeholder will host the EPMS as a centralized and modular solution where discoms can plug-in to avail various services, models, and dashboards etc. Key features of EPMS will be as below:

- Plug-and-Play models – EPMS will be centrally hosted and accessible through web- based dashboards
- Modularity – the solution will be modular such that the participating discoms can select the solution modules as per their requirement and capabilities for higher levels of IT integration
- Data security – Data security should be ensured by following IT protocols and cybersecurity guidelines and regulations
- Separate user interface for each DISCOMs through separate login, SSLs
- Scalable – Modules should have capability to simultaneously support multiple discoms at same time

The following illustrative schematic presents a high-level EPMS system architecture.

Figure 1: Centralized EPMS Architecture



Key component of the proposed EPMS solution should include:

1. **Solution Modules:** central to the EPMS, it will have separate modules for different requirements of the Discoms. The modules are described as below:
   a) Demand forecasting – this module would provide users to forecast demand for short-term. It will take weather forecasts; historical load and weather data; special events, calendar events data as inputs
   b) Unit commitment – this module would provide the optimal generation schedules by considering the constraints and market opportunities available
   c) Markets Platform – it will integrate all the information available from sources such as RLDCs, SLDCs PXs and other platforms to support the user to take best informed decision on power procurement
   d) Price forecasting – this module will forecast the prices at different marketplaces for short

to medium term horizon

e) PXs bid management – this module would take inputs from other modules to prepare optimal bids for different market products such as DAM, GDAM, RTM, GTAM, TAM, HP-DAM and any other upcoming market products like carbon markets etc.

These modules will be preferably automated. However, depending upon the data availability and limitation in IT integration with different sources, these modules can also function based on user-input.

2. **Central Database:** it would be a cloud-based system with redundancies, housing all the data inputs and output reports generated by the solution modules. Data would be collected through various sources such as:
   - RLDC/SLDC- historical demand, real demand, SCADA generators' availability/ entitlement and schedule data
   - Weather forecast service providers- weather forecasts and historical data
   - Power exchanges- bid quantum and prices
   - Generators' data- specifications, constraints etc.

   The system would have the capability to take data inputs as direct input by the users or through APIs in an automated manner.

3. **EPMS operations center** – this would be a set-up at the central location (preferably at central stakeholders' premises). The EPMS operations center will be responsible for keeping the EPMS solution modules running and supporting any integration requirement from identified discoms.

4. **Discoms shift operations team** – a 24x7 shift operations team shall be placed at the identified discoms, for one year to handhold the supporting Discom officials in running the EPMS solution modules.

5. **Web-based user interface** – web-based and mobile app-based dashboards would be provided to the users for data input, running the solution modules and view/download output reports. Depending upon the IT integration achieved these interfaces can be automated to send direct inputs through customized APIs to the SLDC/RLDC and PXs on the generation scheduled and the buy/sell bids/quantum scheduled.

C.2. SPECIFICATIONS

The key activities performed by EPMS are broadly divided in three focal areas:

1. Forecasting
2. Optimization
3. Market participation

1. Forecasting

1.1. Demand forecasting

i. The solution should be able to analyze and forecast demand (in MW and MUs) over short-term time horizons using advanced forecasting techniques while considering a multitude of parameters such as:
   a. Historical and forecasted weather parameters such as temperature, rainfall, wind, humidity from weather service providers (services to be arranged by the solution provider on its own)
   b. Historical demand
   c. Festivals/holidays/weekends/ special social occasions or incidents
   d. Any other factors which will affect demand or consumption

ii. The solution shall provide demand forecasts for 15 minutes/sub-hourly/hourly time-blocks for the following level of granularities:
   a. Intraday demand forecasts
   b. Day-ahead demand forecasts
   c. Week-ahead demand forecasts

iii. The solution should be able to adapt any new regulatory changes such as generating forecasts for 5 minutes time blocks.

iv. Customizable dashboards for the following, among others, must be part of the solution:
   a. Demand forecast (in MW) for 15 minutes/sub-hourly/hourly time blocks for day-ahead, intraday, and week-ahead basis. Frequency of update for 1) Day-ahead forecast – Daily (Before 9 am); 2) Intra-day forecast - Every 15 minutes; 3) Week-ahead forecast – Daily (Before 11:30 am for next 7 days) or as per requirement specified by Discom
   b. Actual vs projected demand data (Actual data to be obtained from SLDC/SCADA)
   c. Forecast performance of different models

   Note: The dashboard reports should be downloadable in csv, pdf, excel formats

1.2. Price forecasting

i. The solution should be able to forecast Market Clearing Price (MCP) for different market products such as DAM, RTM, TAM, GDAM, HP-DAM etc. across Power Exchanges.

ii. Solution should give accurate price forecasting considering the factors such as following:
   a. Historical MCP data
   b. Day-ahead and Term Ahead availability of transmission lines
   c. Region wise shortage and surplus of power
   d. Region wise generation data

iii. Customizable dashboards for the following, among others as specified by the discoms, must be part of the solution:
   a. Price forecast (in MW) for 15 minutes/sub-hourly/hourly time blocks for day-ahead, intraday, and week-ahead basis. Frequency of update for 1) Day-ahead forecast – Daily (Before 9 am); 2) Intra-day forecast - Every 15 minutes; 3) Week-ahead forecast – Daily (Before 11:30 am for next 7 days) or as per requirement specified by Discom

b. Actual vs projected price
c. Forecast performance of different models
d. Weather forecast reports on rolling basis (Daily by 8 am)

Note: The dashboard reports should be downloadable in csv, pdf, excel formats

2. Optimization

2.1. Demand-supply assessment

i. The solution shall aggregate all sources of power tied to the state and generate a demand-supply position map to assess surplus/deficit of power.
ii. To perform this activity, the solution should be able to able to fetch data from multiple sources viz., RLDCs, SLDCs etc. via APIs.

2.2. Unit commitment

i. Solution should support linear, non-linear, and mixed integer optimization using state-of-art solvers to prepare a unit commitment and dispatch schedule for 15 minutes time block on day-ahead and intraday basis to meet the forecasted demand
ii. Following factors, among others, must be considered by the solution to generate the most optimal schedule to meet the demand at the least-cost while using available resources, increasing green energy consumption, and minimizing risks:
    a. Existing PPA contracts and their costs
    b. Existing generation availability including schedule and forced outages
    c. Start up, shut down costs
    d. Technical constraints such as ramp-up, ramp-down, technical minimum, start-up time (hot, warm, cold) etc.
    e. Short-term demand forecasts
    f. Deviation charges
    g. Renewables forecasts as available from SLDC, RLDC and other sources
    h. Policy constraints such as must-run renewables, emissions, etc.
    i. Battery storage, pump storage and constraints etc.
    j. Power exchange price forecasts for different market products such as DAM/GDAM/RTM/TAM/GTAM/HP-DAM
    k. Transmission constrains considering ATC, TTC and TRM limits
iii. The dispatch schedule shall be generated for every time block to accommodate changes in dependent variables viz., variation in forecasted demand, availability of generating stations etc.
iv. Customizable dashboards for the following, among others as specified by discoms, must be part of the solution:
    a. Power supply availability (in MW) for 15 minutes/sub-hourly/hourly time blocks
    b. Demand-supply (in MW) for 15 minutes/sub-hourly/hourly time blocks
    c. Output of the unit commitment module including the dispatch schedules and the buy/sell quantum from the power exchange(s)

d. Real-time DSM dashboard (penalty, volume)
e. Day-ahead bids, Real time bids (updated every half hour), Generation reports (Unit wise/Station wise)
f. Input for demand response program basis optimization (such as quantum and suggested time blocks)

3. Market participation

i. The solution shall consider different market products of the Power Exchange(s) such as DAM/GDAM/RTM/TAM/GTAM/HP-DAM etc. while preparing the market intelligence and strategy report for discoms
ii. The solution shall advise on price and volume risk-mitigation strategies for market participation by discoms
iii. The solution shall have functionality to integrate with new market designs introduced near future such as ancillary services for balancing and contingency (frequency control – fast, slow and delayed) in alignment with SRAS and TRAS regulations issued.
iv. The solution shall be able to interact with multiple Power Exchange(s) to fetch data using APIs
v. Solution shall have functionality of uploading buy/sell bids in the power exchange bidding platforms and its technology integration should be in tandem with PXs latest upgrades
vi. The solution shall provide a market-aggregator dashboard with forecasted MCPs for different products while ensuring historical PXs data availability
vii. EPMS shall generate following reports, among others as specified by discoms:
    a. The solution shall provide a market-aggregator dashboard, among others, with forecasted MCPs for different products while ensuring historical PXs data availability, i.e. dashboards for:
    b. Top buyer and sellers in different market segments
    c. Potential saving and actualized savings through EPMS
    d. Daily block-wise buy/sell volume (MW) and energy (MUs)

    Note: The dashboard reports should be downloadable in csv, pdf, excel formats

4. Other features

4.1. Model specifications

Forecasting

i. The solution should use advanced multivariate and statistical algorithms such as, but not limited to, regression models, ARIMA, neural networks, support vector regression, ant colony and particle swarm optimization Xgboost, LSTM etc.; to analyze and predict demand over various time horizons
ii. Solution should be able to integrate with open-source Machine learning tools, models and framework like Tenser flow, Sagemaker etc.
iii. The solution should be primarily developed using open-source programming languages such as python, R, Julia, C#, etc.