
# Advanced VPP Grid Integration Project

**Preliminary Report – Technical Description of API Implementation**

22/9/2020

SA Power Networks

Empowering South Australia

# Contents

## Purpose

This document is the SA Power Networks Advanced VPP Grid Integration Project Preliminary Report – Detailed Technical Description of VPP API implementation for the ARENA Advancing Renewables Program.

This report explains how the different technologies fit, the user interaction points, data storage, configuration details and data structures to provide a detailed understanding of the solution. This document is intended to be read in conjunction with the API specification published in the *API development portal*.

Any parties interested in discussing the contents of this report directly with SA Power Networks are encouraged to contact Bryn Williams at bryn.williams@sapowernetworks.com.au.

## Disclaimer

This Project received funding from ARENA as part of ARENA's Advancing Renewables Program



## Overview

The Advanced VPP grid integration project has introduced an interface (API) to exchange real-time and locational data on distribution network constraints between SA Power Networks and the Tesla South Australian VPP, enabling the VPP to optimise its output to make use of available network capacity. This concept is being tested in a field trial over 12-months. Refer to the ARENA web site for more about distributed energy resources and related ARENA trials.

# Definitions, Acronyms and Abbreviations

The following table contains a list of terms, acronyms and their definitions used in this document:

| Term | Definition |
|---|---|
| API | Application Programming Interface |
| Cold Storage | Cost effective bulk storage |
| Constraint Node | A theoretical or actual point in the network where a network constraint is estimated / may occur. Eg Substation, Transformer, Feeder, Circuit |
| Operating Envelope Engine | Consolidated name for the Operating Envelope Generator & Mediation Engine |
| Operating Envelope Generator | The algorithm which consumes a variety of data sources to model the state of the network and calculate raw (un-mediated) Operating Envelopes for the entire LV network. |
| DER | Distributed Energy Resources e.g. Tesla Powerwall, Rooftop Solar |
| GIS | Geographic Information System |
| Hot Storage | High performance storage |
| Insolation | Solar Radiation |
| LV | Low Voltage |
| Mediated / Published Operating Envelopes | A rule-based allocation of raw Operating Envelopes to each VPP, by node, site or NMI. The rule may be determined by Government regulations and connection agreements. |
| Mediation | The process of allocating raw (un-mediated) Operating Envelopes to each VPP, by node, site or NMI. |
| Mediation Engine | The algorithm which consumes raw (un-mediated) Operating Envelopes and determines the allocation of Operating Envelopes to each VPP, by node, site or NMI. |
| MUP | Mirror Usage Point – URI address to stream telemetry to |
| NMI | National Meter Identifier – generally one NMI per address or site |
| Operating Envelope / Constraint | The operating bounds for VPP managed DER, estimated in Watts at a constraint node, site or NMI |
| Participant | Virtual Power Plant Operator, Site controller, Monitoring Service Provider, Aggregator |
| PW | Tesla Powerwall (Only DER for the trial) |
| Raw / Un-mediated Operating Envelopes | Operating Envelopes without any allocation rules applied |
| SAPN | SA Power Networks |
| SCADA | Supervisory control and data acquisition |
| SWER | Single wire earth return |
| URI | Uniform Resource Identifier |
| VPP | Virtual Power Plant |

# 1. System Architecture

## 1.1 Capabilities Architecture

The capabilities required to service VPPs and maintain the integrity of the network are grouped into 3 API categories:

- Registration – VPP communication of DER attributes and settings to SAPN's VPP solution
- Monitoring – VPP communication of ongoing DER telemetry
- Operating Envelope – SAPN's VPP solution communication of network capacity for DER generation.

3 SAPN systems are required to service SAPN's VPP API capabilities:

- DER Database – Stores the current and historical state of registered DER
- Time Series Datastore– Time series store of DER telemetry, historical Operating Envelopes and a diverse range of other data that can be used to improve the calculation of Operating Envelopes.
- Operating Envelope Management – calculation of Operating Envelopes from above data stores and other SAPN data.

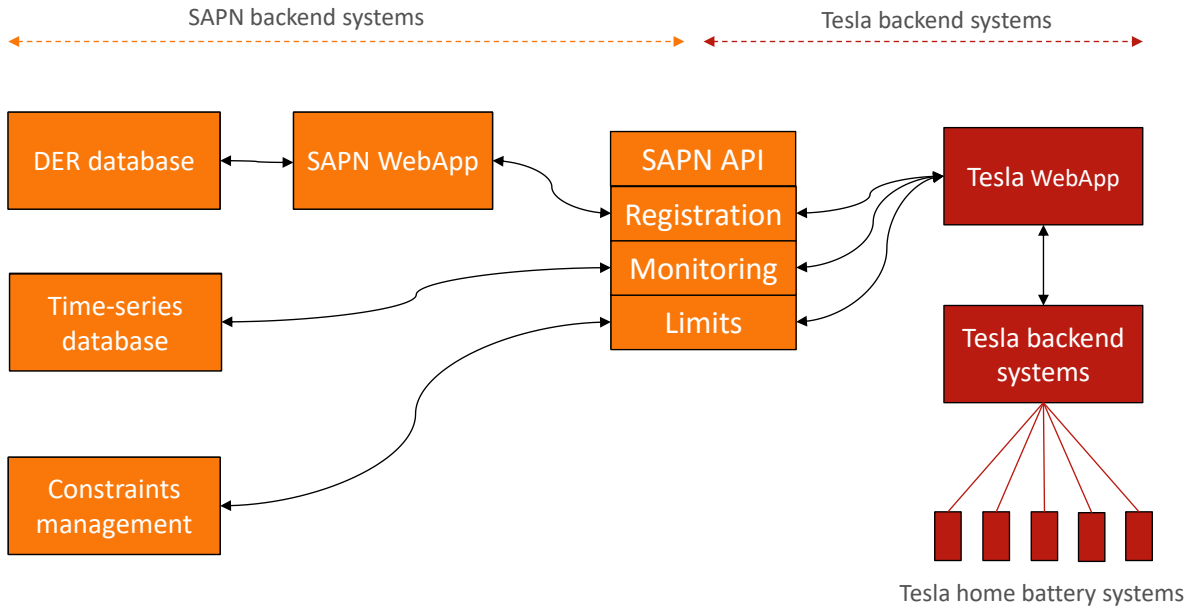



**Figure 1: SA Power Networks - Concept Architecture**

## 1.2 Capabilities & Solution Architecture

The below diagram shows how each logical solution component is used to enable each capability, and how each capability aligns with the SA Power Networks Key capabilities in the above diagram.

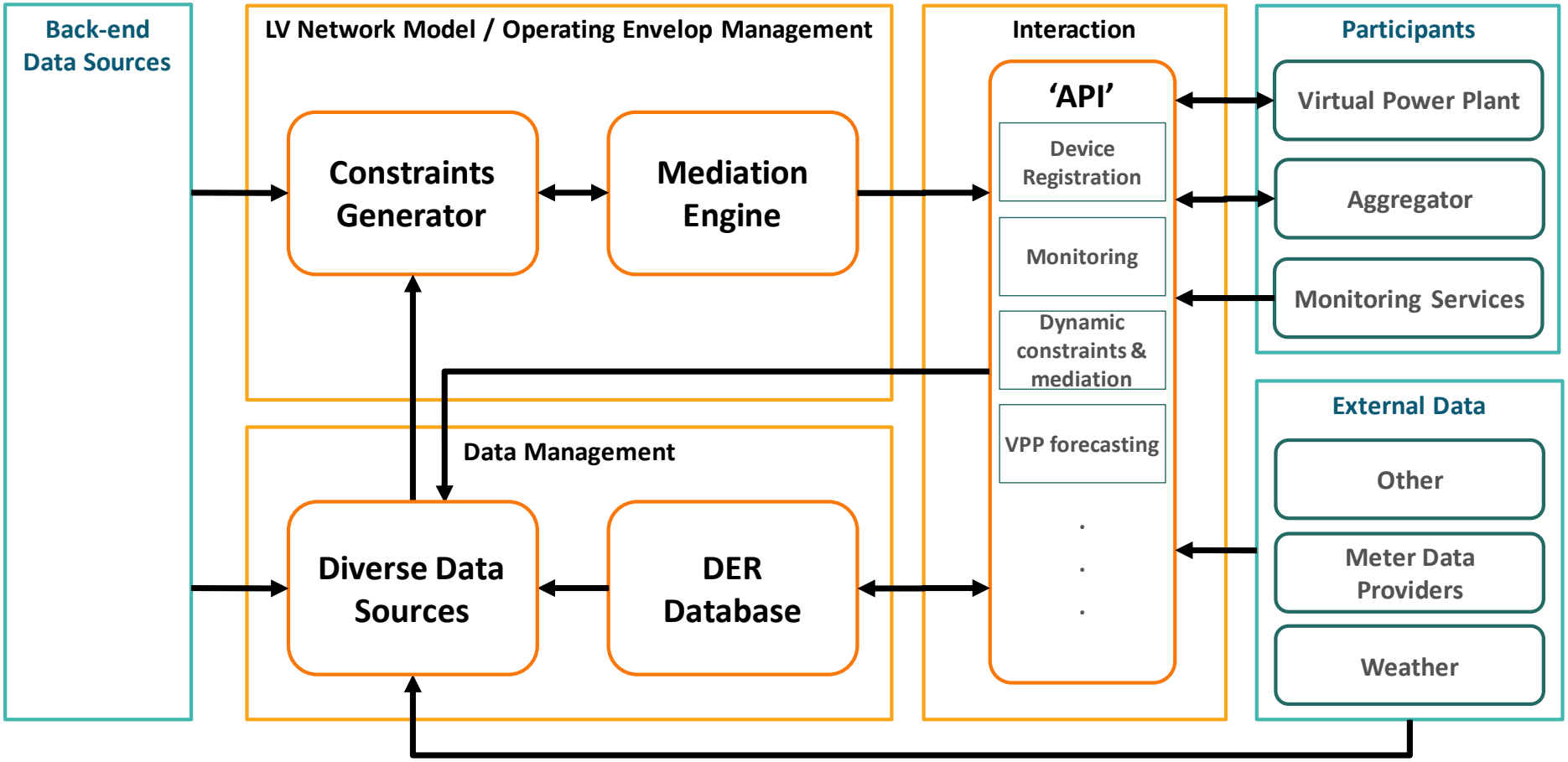



**Figure 2: High Level Future Network Architecture**

# 2. Functional Capabilities

## 2.1 Registration

Participants (VPP) and their related DER are registered within the DER Register. The registration / master data is used as the basis for all other VPP functions.

### 2.1.1 Participant Registration

*e.g. Tesla*

Before being able to interact with the system, the external participant must be registered and provided with a X.509 certificate.

All API functions can only be requested by a valid Participant. The data returned to the Participant is strictly limited to data provided by the Participant (eg. DER / NMI details), and data relating directly to that Participant's DER & NMI's (eg. Constraint Nodes and Operating Envelopes).

Registering the VPP operator is the technical step in the process of onboarding a new VPP.

**Process**

The below process assumes the above manual registration of the new Participant (VPP / Tesla) has been completed.

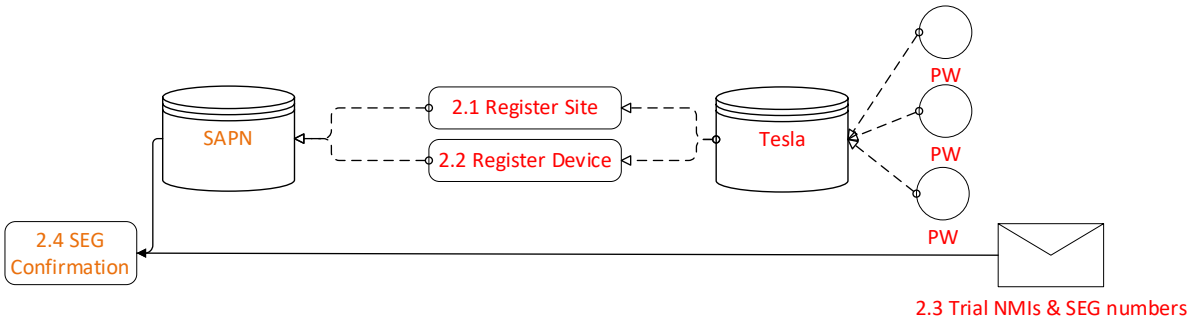



**Figure 3: Device Registration**

### 2.1.2 NMI (Site) Registration

All DER are assigned to a NMI. The NMI is registered as being controlled by a Participant (VPP). The requested NMI registration is validated against NMIs from SA Power Networks' GIS Network Model.

The Participant controlling the site is responsible for ensuring the site net real power is dispatched within the operating envelope.

**Process**

API Call – *Register Site* – See the *API Developer Portal* for details on this API

This call allows the DER to be registered in the same call as registering a NMI

### 2.1.3 Device (DER) Registration

All VPP DER are registered within the DER Register. Detailed attributes are required as part of the registration.

**Process**

API Call – *Register Device(s)* – See the *API Developer Portal* for details on this API and the Attribute Definitions tag for validation requirements.

### 2.1.4 Tesla / VPP Monitoring Process Flow

The table below outlines the API & Architecture steps for the activation of an already registered Device for monitoring.

| Sequence | Step | API Step (Diagram A) | Architecture Steps (Diagram B) |
|---|---|---|---|
| 1 | Tesla Register Device for monitoring | 3.1 | 1, 2 & 3 |
| 2 | SAPN Response MUP URI | 3.2 | 4 & 5 |
| 3 | Tesla sending monitoring data (repeated every 5 mins) | 3.3 | 6, 7 & 8 |
| or 3 | Tesla sending monitoring data (repeated every 24hrs) | 3.4 | 6, 7 & 8 |

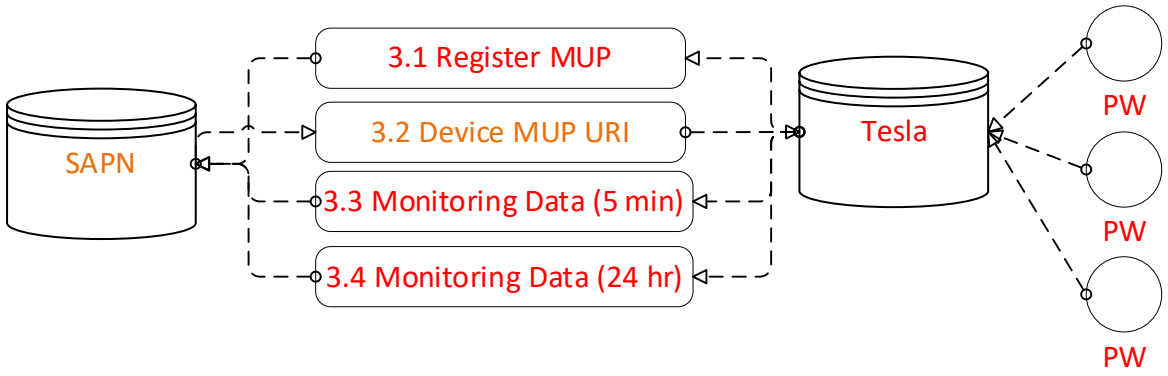



**Figure 4: Diagram A - API Steps**

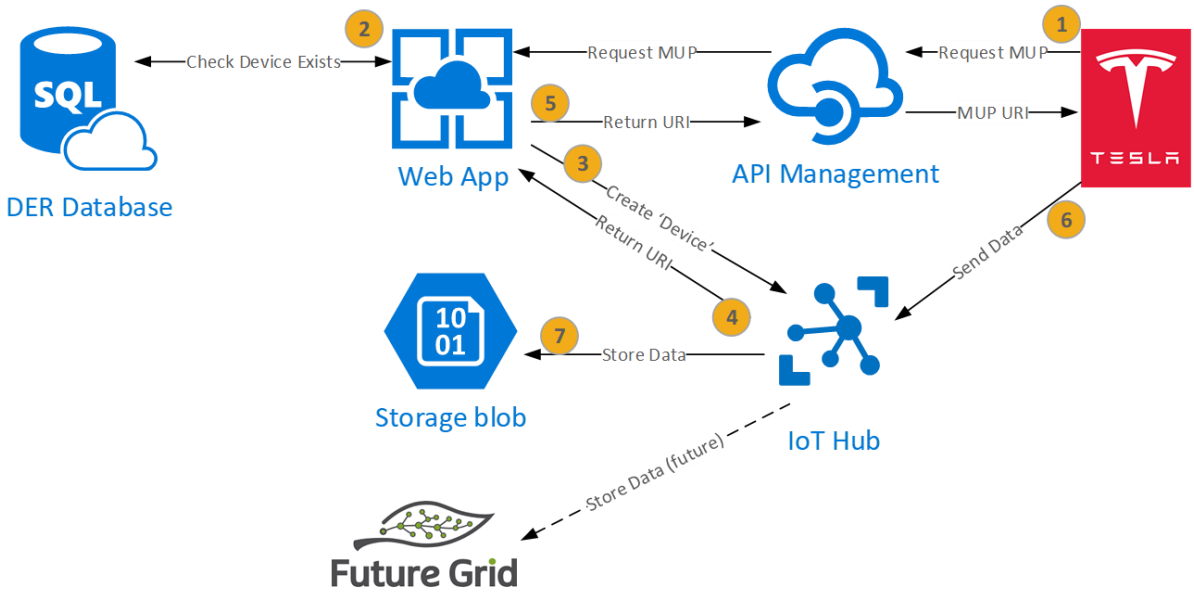



**Figure 5: Diagram B Architecture Steps**

In addition to storing the monitoring data in the IoT Hub cold storage, the same data is also copied to a staging cold storage for Visualisation tool consumption.

### 2.1.5 Tesla / VPP Monitoring Registration

A MUP or Mirror Usage Point is a single target URI for the telemetry data from an individual VPP DER.

The data points to be included are defined by the VPP in the monitoring registration API call. A MUP will be returned for each DER registered for monitoring. All telemetry monitoring data for the respective DER is to be sent to that MUP.

Please see the *VPP Monitoring data schema and reference tables* document for details on this message.

**Process**

API Call – *Register MUP (Device Level)* – See the *API Developer Portal* for details on this API call and the *VPP Monitoring data schema and reference tables* document for details on this message.

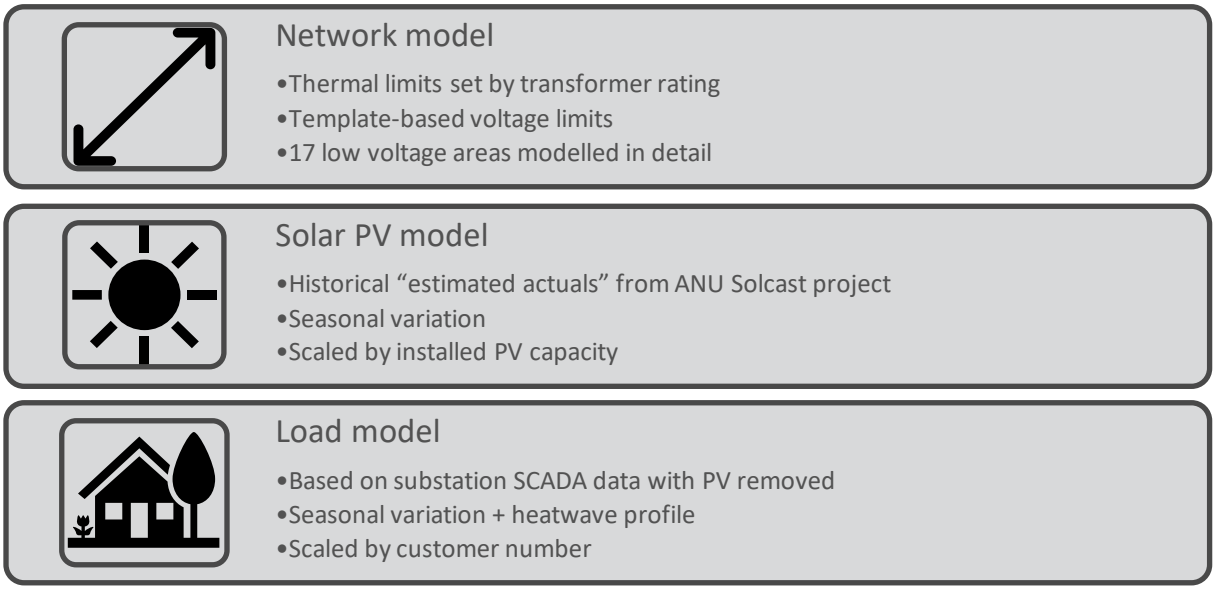
## 2.2 Tesla / VPP Monitoring Data

The measurement points are defined in the *VPP Monitoring data schema*. The received telemetry data is stored for future consumption and analysis (Visualisation tool).

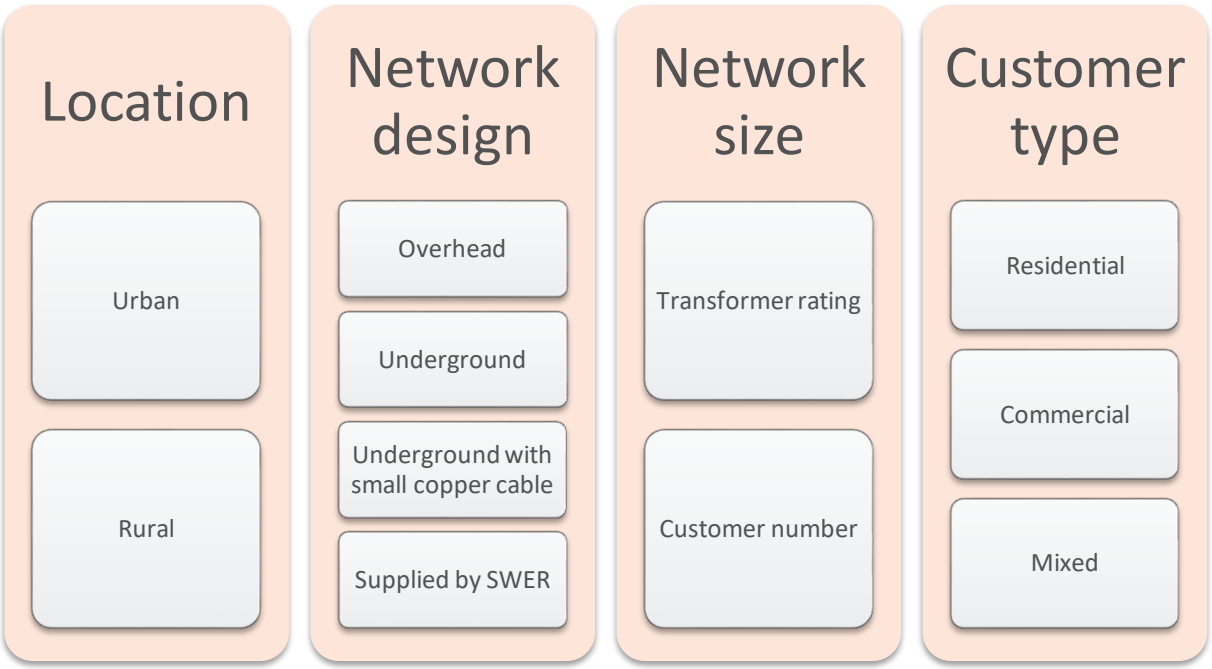
## 2.3 Operating Envelopes

The amount of power a VPP can dispatch at any site occurs within an operating envelope, and this can change every 5 mins due a combination of factors:

- LV Transformer specifications
- Weather
- Season
- Day of the week
- Time of the day
- Solar Forecast
- Outages



**Feeder Modelling**




SA Power Networks calculate this operating envelope at the Constraint Node and provide this operating envelope to the VPP. The VPP may apportion the operating envelope amongst their NMI's mapped to the constraint node.

Mediation across multiple VPP's is not currently within scope.

Below is the sequence of events which enable the VPP to consume their Operating Envelopes and relate them to their NMI's / Sites.

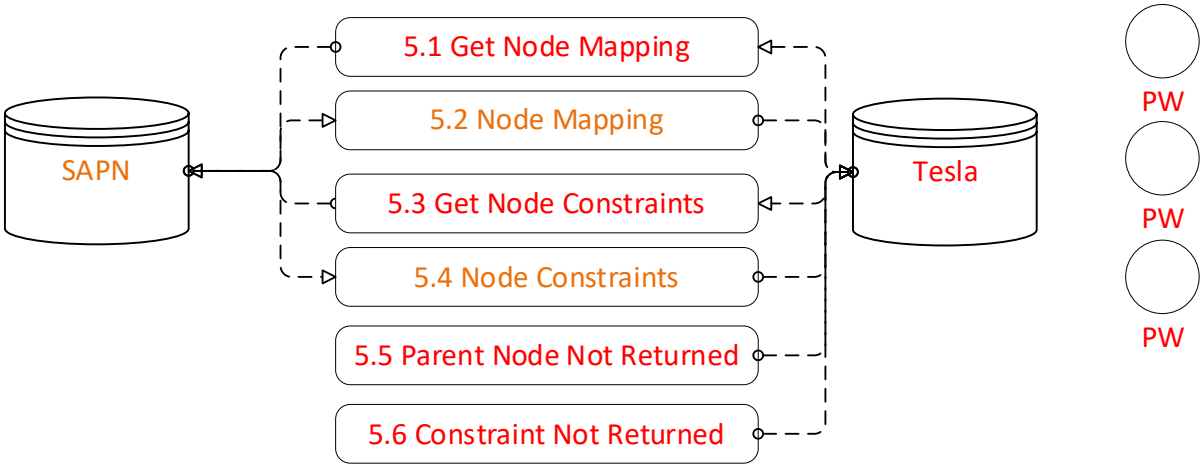



**Figure 6: Constraints API Calls**

### 2.3.1 Get Node / NMI Mapping

Returns the Constraint Node to NMI / Site mapping for VPP sites only. Participant call to SAPN API *Read all Registered Devices/NMIs/Nodes* as per the *API Developer Portal*.

### 2.3.2 Get Constraints

Returns 24hrs of Operating Envelopes for each Constraint Node related to VPP sites. Participant call to SAPN API *Get All Group Limits* as per the *API Developer Portal*.

### 2.3.3 Operating Envelopes Engine

Conceptually, the Operating Envelopes Calculation (Engine) is made up of the Operating Envelopes Generator and Mediation Engine. Both functions are executed within the one application, with Historical & Raw (un-mediated) Operating Envelopes output to cold storage and the current Operating Envelopes output to hot storage for consumption by the API.

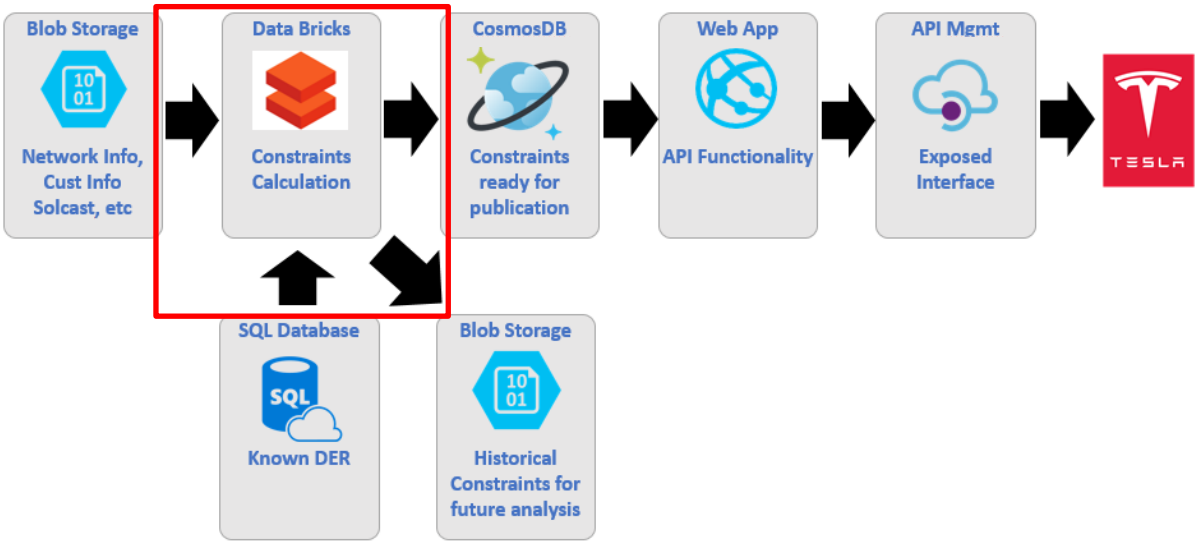



**Figure 7: Operating Envelopes**

### 2.3.4 User Parameters

There are number of parameters available for the user to change the modes and output of Configuration Engine:

| Parameter | Valid Input | Description | Method |
|---|---|---|---|
| **Heat Wave Mode** | Yes / No | Use heat wave energy consumption profiles & alter calculation | Data Bricks Parameter |
| **Confidence Margin (%)** | Number up to 2 decimals | Confidence margin subtracted from calculated Operating Envelope | Data Bricks Parameter |
| **Floor (kW)** | Number up to 2 decimals | Minimum Operating Envelope per NMI | Data Bricks Parameter |

| | | | |
|---|---|---|---|
| **Ceiling (kW)** | Number up to 2 decimals | Maximum Operating Envelope per NMI | Data Bricks Parameter |
| **Excluded Nodes** | Yes / No | Use list of nodes to always output the Floor Operating Envelope | CSV file in Cold storage containing list of Constraint Nodes to be excluded |
| **Testing** | True / False | Used for automated testing in Dev & QAS | Data Bricks Parameter |

### 2.3.5 Data Sources (Cold Storage & SQL Database)

The Operating Envelopes engine utilises data from cold storage and SQL Database.

**Cold storage:**

- Solar profiles
- Demand profiles
- Transformer Prototype data
- Customer Numbers

**SQL Database:**

- DER Database
- NMI / Node mapping

### 2.3.6 Data Output (Cold Storage, Hot Storage)

The Operating Envelopes engine outputs data into cold storage and Hot Storage DB. These are configured in the *IT Configuration* block.

**Cold storage:**

- Archive store of Raw Operating Envelopes for All network nodes
- Archive store of VPP Mediated Operating Envelopes

**Hot Storage DB:**

- Temporary store of current VPP Mediated Operating Envelopes servicing the API

# 3. References

The following table contains a list of references, documents and link used in this document:

| Reference | Location / Document |
|---|---|
| API Developer Portal | "SA Power Networks developer portal.pdf"<br>For access to the live portal please contact SA Power Networks |
| VPP Monitoring data schema and reference tables | Navigate to the MUP Definition tab via the attached *API Developer Portal* documentation |