Low Voltage (LV) Planning Engine Review

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Prepared for SA Power Networks

blunomy®

Authors

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Enquiries on this report should be directed to:
Pierre Lelong
Managing director
[redacted]

Authors:
Constanza Iribarren
Pierre Lelong

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This report is intended to be published on the AER's website as part of SA Power Networks' regulatory proposal. The report outlines Blunomy's review process of SA Power Networks' (SAPN) tool for Customer Energy Resources (CER) network expenditure calculation, the Low Voltage (LV) Planning Engine. This report is:

- *Limited in scope, focusing on methodology and modelling approach discussions, excluding investment plan results analysis.*
- *Based on information compiled in workshops and discussions in March, September, and November 2023. Blunomy disclaims liability for any errors or omissions in the information provided by SAPN*
- *Not an exhaustive explanation of the LV Planning Engine; it should be read in conjunction with SAPN's "CER integration modelling methodology" report.*

EXECUTIVE SUMMARY

SA Power Networks (SAPN) is South Australia's regulated electricity distributor, serving over 860,000 customers. The region has seen a significant increase in Customer Energy Resources (CER), such as rooftop solar, electric vehicles and batteries, and this trend is expected to continue, according to the Australian Energy Market Operator's (AEMO) forecasts. In particular, the volume and pace of rooftop solar uptake are increasingly pushing the network closer to its operational limits.

Increasing solar rooftop generation at the customer level can cause various issues on existing distribution networks. Most of these issues occur at the edge of the distribution network, the Low Voltage (LV) network, where most residential and small commercial and industrial customers connect.

The first issue encountered when solar rooftop generates electricity is voltage rise. High export levels of behind-the-meter power generation to LV networks during periods of low customer demand can increase the voltage above operational limits. Additionally, solar production at customer premises can cause power to flow back upstream, which can exceed the thermal limits of the distribution network.

Distribution network service providers (DNSPs) are responsible for maintaining network safety, reliability and power quality. To mitigate the impact of solar generation, DNSP can prevent such generation (this is called 'curtailment'). DNSP can also implement solutions to reduce future curtailments, such as distribution transformer capacity upgrades, substation voltage control, tapping distribution transformers, or infill transformers. However, DNSP must ensure that the benefits outweigh the costs before implementing these solutions.

About this report

As a part of its Regulatory Proposal 2025-30, SAPN's Energy Transition team developed the Low Voltage (LV) Planning Engine, a software tool that assesses required investments to mitigate issues linked with CER uptake.

SAPN requested Blunomy to independently review the LV Planning Engine as part of its quality assurance process. The review focused on the approach and modelling decisions within SAPN's LV Planning Engine's four main building blocks:

- Power flow
- Constraint Identification and Valuation
- Solution Map
- Solution Evaluation.

Blunomy also reviewed SAPN's modelling approach for hosting capacity[1], a key input to the LV Planning Engine. The review did not include results quality analysis or code review.

This report presents an overview of the collaboration between Blunomy and SAPN. It highlights Blunomy's recommendations for hosting capacity calculations and each LV Planning Engine building block, the assessment of the implemented recommendations, and outstanding improvements.

About SAPN's and Blunomy's collaboration

In March 2023, almost a year before SAPN's 2025-30 Regulatory proposal, Blunomy and SAPN began collaborating on the review of the LV Planning Engine. In Phase 1, Blunomy identified and recommended SAPN 16 improvements on the LV Planning Engine. Between March 2023 and January 2024, SAPN upgraded the tool, implementing 12 of the most material recommendations, fully or partially.

[1] Defined as the quantity of net power flow that a distribution transformer can support without generating voltage or thermal constraints. See Section "4.1 What is Hosting Capacity" of SAPN's "CER integration modelling methodology for additional information.

In Phase 2, from October 2023, Blunomy conducted an additional review of the updated LV Planning Engine. The collaboration resulted in the compilation of this report, highlighting SAPN's dedication to developing the LV Planning Engine.

SAPN could not fully implement some key recommendations, mainly due to the unavailability of comprehensive smart meter data. SAPN's team is working on finding an acceptable balance between the costs of acquiring data and the robustness of hosting capacity assumptions.

Review of the LV Planning Engine

The LV Planning Engine models future rooftop solar power export, identifies constraints (curtailment occurrences) and assesses the suitability of solutions (e.g. tapping, voltage control, network upgrade, etc.) to generate an investment plan. SAPN uses a hybrid approach that evaluates and prioritises potential solutions along two dimensions:

- **Export service performance**. A high export service performance corresponds to a situation where rooftop solar export customers see little or no curtailment in solar production.
- **Economic value increase.** The economic value is the benefit of avoiding energy curtailment, calculated by multiplying the amount of curtailed energy avoided by the Customer Export Curtailment Value (CECV), provided by the Australian Energy Regulator (AER).

SAPN generated its CER investment plan using a six-step energy transition modelling process[2], following AER's recommendations in the "Distributed energy resources integration expenditure guidance note. "

SAPN's modelling approach for hosting capacity (or the Hosting Capacity block) and the LV Planning Engine enable the different steps of SAPN's energy transition modelling process, presented in Figure 1.

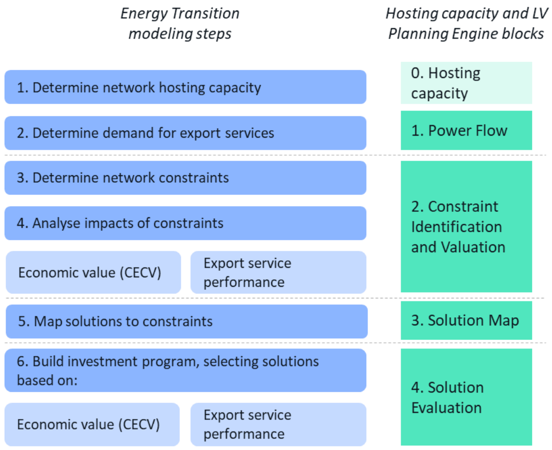

Figure 1. SAPN's Energy Transition modelling process

The hosting capacity block estimates each transformer's hosting capacity limits (voltage and thermal). These values are a key input into the LV Planning Engine.

Blunomy recommended SAPN improving the hosting capacity calculations using smart meter data and avoiding a categorical approach.

SAPN partially implemented this recommendation, substantially improving the hosting capacity model, but was confronted with data limitations. Currently, SAPN uses three different approaches depending on data availability:

- The first uses direct inference when enough smart meter data is available,
- The second uses a linear regression with partial data, and
- The third calculates an average categorical hosting capacity for transformers without a smart meter. Due to low smart meter data availability, SAPN applies this method to 97% of transformers.

The power flow block forecasts 25-year CER uptake and corresponding export and calculates the power flow at the LV transformer level.

Blunomy identified eight low to medium-materiality recommendations in this block, mostly

[2] The energy transition modelling process is described in Section "3. Modelling Overview & Architecture" of SAPN's "CER integration modelling architecture" report.

related to CER and discretionary[3] load uptake and profiles. SAPN implemented four of these recommendations upgrading load growth assumptions, CER and discretionary load profiles, among others.

The current version of the tool applies the same CER uptake for all the customers within a postal code. This might lead to some residual discrepancies at the transformer level. Blunomy considers outstanding improvement minor/medium, and additional tests would be beneficial to quantify their materiality.

The constraint identification and valuation block identifies transformer constraints by matching the anticipated rooftop solar export to the hosting capacity limits. For these constraints, the tool calculates the forecasted curtailed energy, economic losses, and impacts on the export service performance (linked to the frequency of curtailment a customer would experience).

Blunomy's main constraint identification recommendations are linked to hosting capacity inputs and are therefore presented in Section 3.2 Hosting capacity review.

The solution map block identifies the available solutions to each transformer with constraints depending on the network's characteristics. To assess each solution's impact, SAPN uses a multiplier factor to increase the hosting capacity.

Blunomy recommended aligning the multiplier factor with empirical data. SAPN implemented this recommendation by conducting before/after tests on one solution (tap) and is still gathering additional empirical information for other solutions.

The solution evaluation block generates a network investment plan to achieve the targeted export service performance, selecting solutions with the best return on investment (benefit generated relative to implementation costs).

Blunomy suggested improvements to the cost-benefit analysis (CBA) structure, which SAPN implemented, generating a more robust and flexible model. Blunomy did not review the investment plan results.

Conclusions and next steps

Blunomy and SAPN's collaboration allowed significant improvements in the LV Planning Engine and increased confidence in the modelling decisions.

The main outstanding improvements are linked to the Hosting Capacity model. Considering the existing data limitations, Blunomy believes that SAPN's current approach allows forecasting network constraints correctly and prioritising solutions according to SAPN's objectives.

As next steps, Blunomy recommends:

- Continuing hosting capacity assumptions refinement using additional smart meter data and reducing the dependency on categorical approaches.
- Continuing to conduct sensitivities and tests with additional smart meter data to increase confidence in the model.
- Gradually fine-tuning power flow assumptions (solar rooftop, electric vehicle, electric batteries, discretionary load, weather), to enhance alignment at the transformer level.
- Increasing non-network solutions in the LV Planning Engine if their business cases evolve in the regional context.

Beyond this submission, the LV Planning Engine will serve for business-as-usual network planning. This will generate additional requirements that should be addressed in further tool versions.

[3] SAPN includes in discretionary load the consumption of both residential and commercial customers caused by air-conditioning, electric hot water systems, electric cooktops, and any other electrical appliances within a home or business. See Section "5.2 Discretionary Load" of SAPN's "CER integration modelling methodology" for additional information.

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Table of abbreviations

AER	Australian Energy Regulator
BESS	Battery Energy Storage Systems
CBA	Cost-Benefit Analysis
CER	Customer Energy Resources
DNSP	Distribution Network Service Provider
EAMO	Australian Energy Market Operator
EV	Electric Vehicle
GIS	Geographical Information System
LV	Low Voltage
PV	Photovoltaics
SA	South Australia
SAPN	Soth Australia Power Networks
SWER	Single Wire Earth Return
ToU	Time of Use

1) Introduction

1.1 Context and objectives

SA Power Networks (SAPN) is South Australia's regulated electricity distributor, serving over 860,000 customers.

The region has seen significant increase in Customer Energy Resources (CER), with for example, rooftop solar accounting for more than 17% of the total electricity generation in 2022-23. Forecasts from the Australian Market Operator (AEMO) suggest that the CER trends will continue, pushing the system closer to its operational limits.[4]

Increasing solar rooftop generation at the customer level can cause various issues on existing distribution networks. Most of these issues occur at the edge of the distribution network, the Low Voltage (LV) network, where most residential and small commercial and industrial customers connect.

The first issue encountered when solar rooftop generates electricity is voltage rise. High export levels of behind-the-meter power generation to LV networks during periods of low customer demand can increase the voltage above operational limits. Additionally, solar production at customer premises can cause power to flow back upstream, which can exceed the thermal limits of the distribution network.

Distribution network service providers (DNSPs) are responsible for maintaining safety, reliability and power quality on their network. To mitigate the impact of solar generation, DNSP can prevent such generation (this is called 'curtailment'). DNSP can also implement solutions to reduce future curtailments, such as distribution transformer capacity upgrades, substation voltage control, tapping distribution transformers, or infill transformers. However, DNSP must ensure that the benefits outweigh the costs before implementing these solutions.

As a part of its Regulatory Proposal 2025-30, SAPN's Energy Transition team developed the Low Voltage (LV) Planning Engine, a software tool that assesses required investments to mitigate issues linked with CER uptake.

SAPN requested Blunomy to independently review the LV Planning Engine as part of its quality assurance process.

This report outlines the collaboration between Blunomy and SAPN throughout the LV Planning Engine review and highlights the main recommendations and improvements made.

It is important to note that the information contained in this report does not include detailed explanations of the methodology and should be read alongside the SAPN's "CER integration modelling methodology" report.

Both reports, Blunomy's "LV Planning Engine Review" and SAPN's "CER integration modelling methodology" are part of the documentation related to SAPN's 2025-30 regulatory proposal.

See Section "2. Background" of SAPN's "CER integration modelling methodology" for additional information.

1.2 Scope of the Review

The review focused on the approach and modelling decisions within SAPN's LV Planning Engine's four main building blocks:

- Power flow
- Constraint Identification and Valuation
- Solution Map
- Solution Evaluation.

Blunomy also reviewed SAPN's modelling approach for hosting capacity[5], a key input to the

[4] Source: South Australian Electricity Report, November 2023, AEMO

[5] Defined as the quantity of net power flow that a distribution transformer can support without generating voltage or thermal constraints. See Section "4.1 What is Hosting Capacity" of SAPN's "CER integration modelling methodology for additional information.

LV Planning Engine. The review did not include results quality analysis or code review.

Blunomy's assessment focuses on the approach and modelling decisions made for the hosting capacity and the four LV Planning Engine main blocks and does not include a code review.

1.3 Structure of this report

Blunomy's LV Planning Engine Review report includes an overview of the collaboration between Blunomy and SAPN, along with Blunomy's recommendations for each building block.

Section 2 of the report highlights Blunomy and SAPN's work between March 2023 and January 2024 to generate an improved version of the LV Planning Engine.

Section 3 presents Blunomy's review of the hosting capacity model and the four main building blocks of LV Planning Engine, highlighting:

- Overview of the building blocks
- Implemented recommendations, and
- Outstanding improvements.

2) Blunomy's collaboration with SAPN

2.1 Collaboration overview

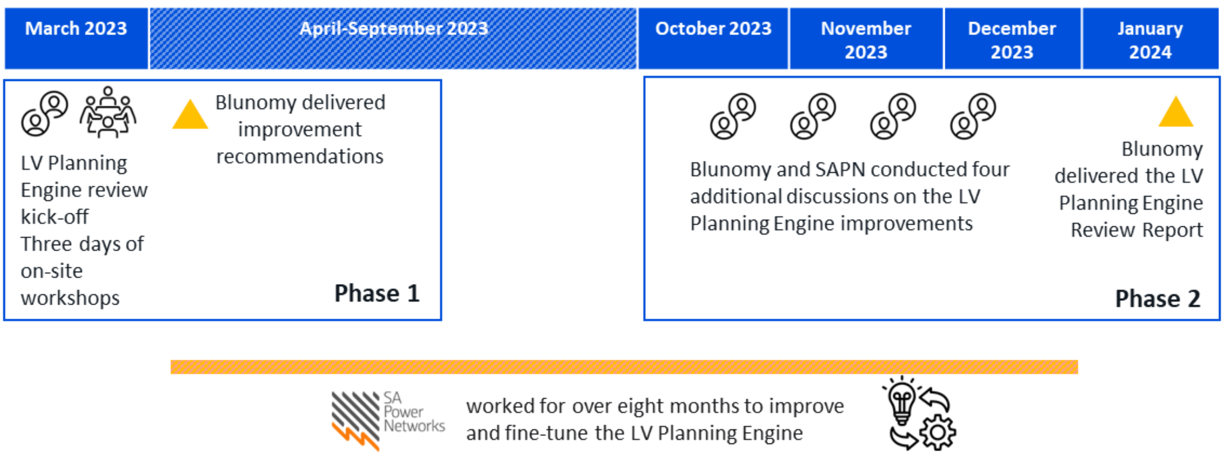


Figure 2. Blunomy's and SAPN's 2023 collaboration to review the LV Planning Engine

In March 2023, almost a year before SAPN's 2025-30 Regulatory proposal, Blunomy and SAPN began collaborating on the review of the LV Planning Engine. SAPN requested an external review of the LV Planning Engine primary modelling decisions and their capacity to generate the expected investment plan results.

In Phase 1, Blunomy assessed the previous version of SAPN's LV Planning Engine. In March 2023, Blunomy and SAPN's Energy Transition team held two preparatory meetings, conducted document reviews, and participated in three full-day workshops at SAPN's offices.

Blunomy identified several areas for improvement. Figure 3 summarises the main gaps shared in March 2023.

Blunomy recommended 16 improvements for the LV Planning Engine and hosting capacity and suggested additional tests to increase confidence in the models. Blunomy prioritised the recommendations based on their materiality[6] and expected impact on the investment plan (under or over-spend). Between March 2023 and January 2024 SAPN upgraded the LV Planning Engine, using Blunomy's recommendations.

In Phase 2, from October 2023, Blunomy conducted an additional review of the updated LV Planning Engine.

Between October and November 2023, SAPN's Energy Transition team and Blunomy conducted document reviews and four meetings to discuss the tool's development, resulting in the compilation of this LV Engine Planning Report.

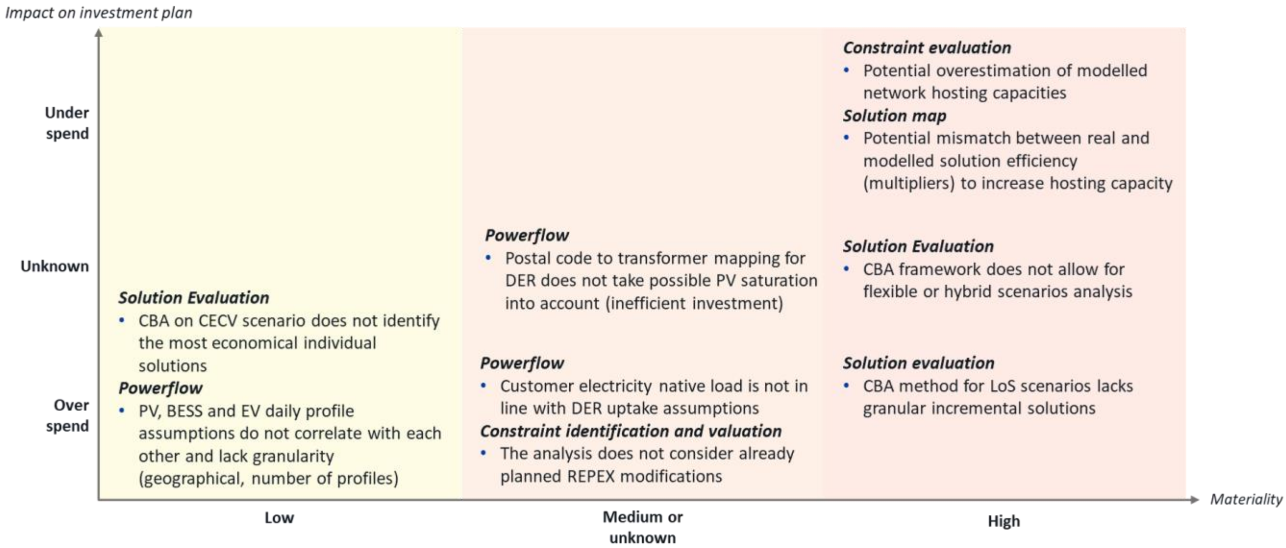


Figure 3. Illustration of main gaps identified during Phase 1 of Blunomy's and SAPN collaboration

2.2 Key takeaways from the collaboration

Blunomy and SAPN worked together to improve the LV Planning Engine approach. Blunomy identified and recommended SAPN 16 improvements for the LV Planning Engine. Between March 2023 and January 2024, SAPN implemented 12 of the most material recommendations, fully or partially, significantly enhancing the approach.

SAPN's team conducted additional tests to improve the confidence in the model's accuracy.

The collaboration highlights SAPN's Energy Transition team's dedication to developing the LV Planning Engine and generating the CER expenditure plan.

SAPN could not fully implement some recommendations, mainly due to the unavailability of comprehensive smart meter data. SAPN's team is currently working on finding the right balance between acquiring data and the tool's effectiveness.

[6] The materiality corresponds to an estimated level of impacts derived from the workshops conducted with SAPN. Blunomy did not perform a quantitative analysis.

3) Review of the LV Planning Engine

3.1 LV Planning Engine Overview

The LV Planning Engine is SAPN's tool to generate an optimised investment plan for CER uptake, which forms part of the Energy Transition portion of SAPN's 2025-30 Regulatory Proposal.

The LV Planning Engine models 2025-50 future rooftop solar power export, identifies constraints (curtailment occurrences) and assesses the suitability of solutions (e.g. tapping, voltage control, network upgrade, etc.) to generate an investment plan.

SAPN implemented a hybrid approach to prioritise the alleviation solutions. The hybrid approach follows two optimisation objectives:

- First is the **export service performance**. The LV Planning Engine generates expenditure plans to achieve export service targets. The level of service is calculated dividing the minutes with constraints in solar exports by the daylight minutes each year.
  A high export service performance corresponds to a situation where rooftop solar export customers see little or no curtailment in solar production.
- The second objective is the **economic value increase.** The Economic value is the benefit of avoiding energy curtailment, calculated by multiplying the amount of curtailed energy avoided by the Customer Export Curtailment Value (CECV), provided by the Australian Energy Regulator (AER).

See Section "6.2 Constraint Valuation" and "6.3 Export Service analysis of SAPN's "CER integration modelling methodology" for additional information.

Figure 4 presents SAPN's Energy Transition modelling process. The different parts of the modelling process are embedded in the hosting capacity model and the LV Planning Engine main blocks.

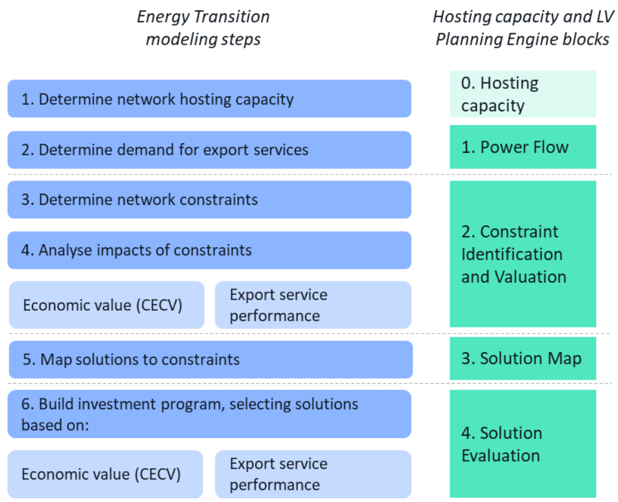


Figure 4. SAPN's energy transition modelling process. Source: SAPN's "CER integration modelling methodology".

0. Hosting capacity model:
Estimates each transformer's hosting capacity (voltage and thermal). These values are a key input into the LV Planning Engine.

1. Power flow:
Forecasts 25-year CER export demand and calculates power flow at the LV transformer level.

2. Constraint identification and valuation:
Identifies transformer constraints by matching the anticipated rooftop solar export to the estimated hosting capacity limits and calculates related CECV and export service performance.

3. Solution map:
Identifies the available solutions to each transformer, depending on its characteristics and current state.

4. Solution evaluation:
Generates a network investment plan to achieve the selected export service performance target with the best return on investment.

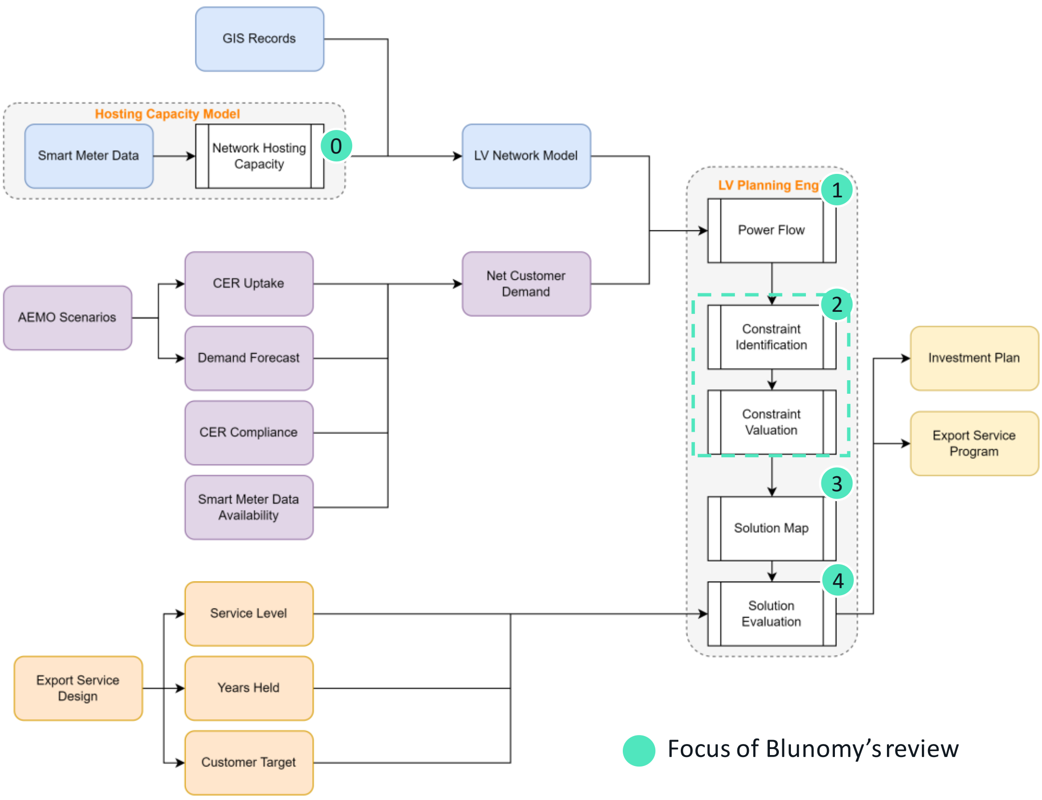


Figure 5. LV Planning Engine high-level architecture. Source: SAPN's "CER integration modelling methodology", adapted by Blunomy

See Section "3. Modelling Overview & Architecture" of SAPN's "CER integration modelling methodology" for additional information.

3.2 Hosting capacity review

3.2.1 Overview

SAPN's low voltage network model describes SAPN's 77,000 transformer-network. It compiles network information, Geographical Information Systems (GIS) records and SAPN's estimations of each transformer's hosting capacity.

Blunomy considers the hosting capacity modelling approach critical for the LV Planning Engine. SAPN defines the hosting capacity in its "CER integration modelling methodology" as:

"The quantity of net power flow that a distribution transformer can support before either:
a single customer supplied by that transformer receives a connection point voltage above 253V, or; the cyclic thermal rating of an upstream distribution network asset is exceeded."

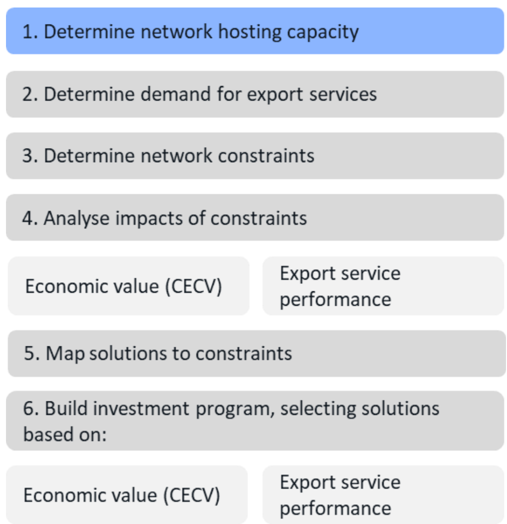


Figure 6. Hosting capacity block focus in SAPN's Energy Transition modelling process

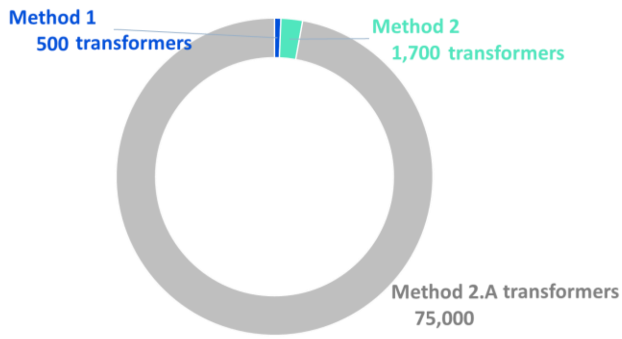
Thermal hosting capacity limits are determined using the transformer type and "nameplate" information of the transformer.

To estimate the voltage hosting capacity limits SAPN needs sufficient smart meter data from customers connected to a transformer. SAPN estimated that this data is required for at least 20% of the connected customers. However, this level of data is only available for 2.2% of the transformers.

Due to this limitation, SAPN has adopted three methods to determine the hosting capacity of a transformer. The method used for an individual transformer depends upon the quantity and validity of smart-meter power data available from customers supplied by that transformer:

- **Method 1 for hosting capacity calculation:** Direct inference using smart meter data. Only applicable for transformers with readings over 258V.
- **Method 2 for hosting capacity calculation:** Linear regression using smart meter data. For transformers without readings over 258V and with enough smart meter data. Data requirements defined in the "CER integration modelling methodology" report.
- **Method 2.A for hosting capacity calculation**: For transformers without smart meter data. SAPN uses an average categorical hosting capacity based on Method 2 estimations.

Figure 7. Share of hosting capacity calculation



methods used in SAPN's network

See Section "4. Modelling Network Hosting Capacity" of SAPN's "CER integration modelling methodology" for additional information.

3.2.2 Implemented recommendations

SAPN improved considerably its approach for hosting capacity calculations since Blunomy's initial review.

Implemented recommendations (fully or partially)	Materiality	Blunomy's comments
Use hosting capacity values calculated with smart meter information	High materiality	In March 2023, SAPN generated the hosting capacity assumptions with 2018 data, that divided the network into 15 categories. Since then, SAPN has made significant improvements by switching to the use of smart meter observations. However, the availability of data remains a limitation, affecting SAPN's capability to rely solely on smart meters. The team has developed an alternative approach with different methods used depending on the data availability for each transformer.

3.2.3 Outstanding improvements

Some outstanding improvements remain, mostly linked to smart meter data availability limitations.

Outstanding improvements	Materiality	Blunomy's comments
Refine categorical mapping of transformers hosting capacity	Medium or unknown materiality	SAPN still uses a categorical approach with a unique hosting capacity per category in Method 2.A for most of the transformers. This approach generates uncaptured hosting capacity variability. Without additional information on actual hosting capacity values, Blunomy cannot confirm the materiality of the outstanding improvement. The 15 categories created in 2018 are still used to describe 97% of the network. SAPN plans to build machine learning models. Blunomy recommends reworking this approach as soon as possible. SAPN's team is working on finding an acceptable balance between the costs of acquiring data and the robustness of hosting capacity assumptions.

3.3 Power flow review

3.3.1 Overview

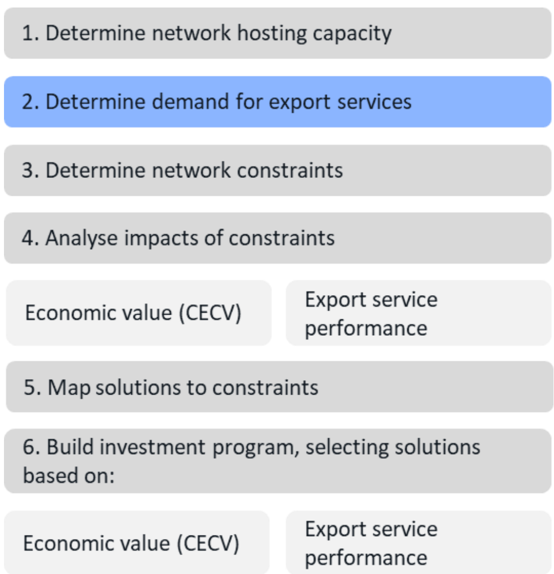


Figure 8. Power Flow's focus in SAPN's Energy Transition modelling process

The power flow block is the second step of SAPN's energy transition modelling process and the first architectural block of the LV planning Engine.

It generates a net power flow forecast for each transformer in the network from 2025 to 2050 using customer demand projections and a low voltage network model.

Step 2. Determine demand for export services:

To determine export demand, SAPN built the net customer demand model by compiling CER and demand forecasts:

- **CER Uptake:**
  CER uptake assumptions encompass various components, such as rooftop solar, batteries, and electric vehicles.

  SAPN relies on AEMO state-level forecasts. SAPN engaged different consultants to execute

state-level to postal code mapping[7]. For postal code to transformer level extrapolation, the tool uses an equitable distribution among customers.
SAPN has generated various thirty-minute CER profiles assumptions using smart meter data whenever possible.

- **Demand forecast:**
  Based on smart meter data, the discretionary load considers different profiles, including residential, residential with electric hot water, and commercial. These profiles also consider Time of Use (ToU) tariff behaviours.

SAPN's power flow model incorporates the expected impacts of other investment programs, like its CER compliance and demand flexibility programs, as inputs (not included in the review). This allows SAPN to consider non-network solutions in the LV Planning Engine.

3.3.2 Implemented recommendations

Blunomy identified several gaps in the power flow block, which mainly relate to the CER forecast assumptions. SAPN made various improvements to enhance the power flow block.

See Section "5. Modelling Demand for Export Services" of SAPN's "CER integration modelling methodology" for additional information.

Implemented recommendations (fully or partially)	Materiality	Blunomy's comments
Ensure consistency between PV uptake and load growth in new development areas	●	SAPN substantially improved the approach by including both discretionary load and PV growth assumptions, ensuring consistency at the state level and post-code level (using AEMO's scenarios and consultant work). However, the current method applies the same CER uptake for all the customers within a postal code. This might lead to some residual discrepancies at the transformer level.
Increase the number of EV charging profiles, depending on the type of customers expected in the zone	●	SAPN increased the number of EV charging profiles representing different behaviours.
Possibility of increasing the number of consumer profiles (discretionary load)	●	SAPN significantly evolved its load profile assumptions. The original profiles were based on 2019 studies and showed theoretical behaviours for different sectors. These have been replaced with smart meter-generated profiles, each with two versions: a low-orchestration/low-price-responsive version based on historical flat tariff and a high-orchestration/high-price-responsive version based on ToU tariffs.

[7] For EV, Evenergi. For other CER, Blunomy. A different delivery team within Blunomy conducted the CER forecasts from state level to postal code level mapping.

Include future profile evolutions such as electrification		SAPN's latest tool version includes additional features, such as discretionary load considering electricity pricing response behaviours and electric hot water load management. The model also includes as a sensitivity option with the AEMO Strong Electrification scenario.

Legend used for the recommendations:

Low materiality Medium or unknown materiality High materiality

3.3.3 Outstanding improvements

SAPN has deprioritised some of Blunomy's power flow recommendations for this submission due to their low materiality . If included in future tool versions, they could fine-tune the modelling approach. Blunomy views these outstanding improvements as having low to medium materiality.

Outstanding improvements	Materiality	Blunomy's comments
Prioritise increase in PV on customers without existing PV installations		The current calculation method does not consider existing rooftop solar installations in a postal code, which may cause discrepancies at the transformer level. The magnitude of the potential impact on the overall investment envelope is unclear without conducting additional tests.
Generate BESS profiles matching solar profiles		After Blunomy's initial review, SAPN added an additional BESS profile to correspond to solar shifting. However, the profile is not linked to the PV profile, which may cause some minor discrepancies.
Improve the granularity of PV profiles, by considering geographical irradiance data (satellite information available)		SAPN currently uses a single rooftop solar production profile for SA. SAPN did not prioritise this improvement given its expected low materiality. SAPN shared that the latitude irradiance variations in the region are around 10% and a high proportion of the network is near the reference irradiation band.
Generate a different profile or performance assumption for customers with existing PV		When customers extend their PV installations to cover a wider surface, the new capacity will likely have a different PV profile. To determine if a new PV profile is necessary, Blunomy recommends calculating the share of new capacity that will fall under this case.

Legend used for the recommendations:

Low materiality Medium or unknown materiality High materiality

3.4 Constraint identification and valuation review

3.4.1 Overview

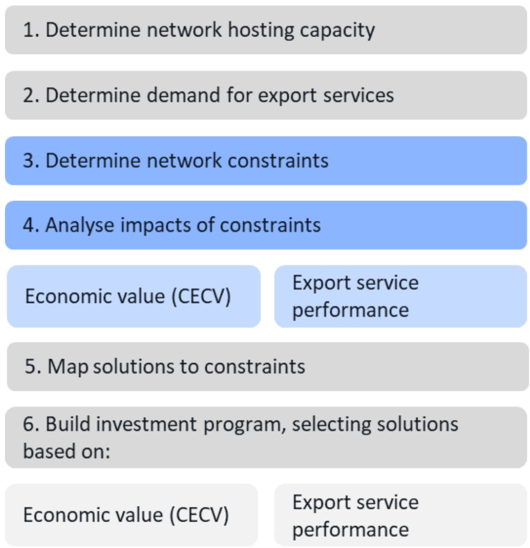


Figure 9. Constraint identification & valuation focus in SAPN's Energy Transition modelling process

The LV Planning Engine uses the network's demand for export services and the estimated hosting capacity to determine and quantify export constraints for each of the transformers from 2025 to 2050.

Step 3. Determine network constraints:

The LV Planning Network identifies network constraints by comparing the projected power flow to the estimated hosting capacity. The model predicts two types of constraints each half-hour, i.e., thermal or voltage, and each is linked to different solutions to alleviate constraints.

Step 4. Analyse impacts of constraints:

For each forecasted thermal or voltage constraint, the LV Planning Engine calculates economic (CECV) and export service performance impacts, which are used for a cost-benefit analysis in the next step of the process.

Blunomy's recommendations on the constraint identification and valuation blocks are mostly linked to the hosting capacity assumptions. They were presented in Section 3.2. Hosting capacity model review.

See Section "6.1. Constraint Identification" and "6.2. Constraint Valuation" of SAPN's "CER integration modelling methodology" for additional information.

3.5 Solutions Map Review

3.5.1 Overview

Step 5. Map solutions to constraints:

The LV Planning Engine uses solution trees to map available solutions to each transformer, built with the empirical knowledge of SAPN's network planning team. The solution trees exclude non-viable solutions starting from the least cost option.

Different solutions are included in the analysis for thermal and voltage constraints, as presented in Section "7. Selecting Constraint Remediations" of SAPN's "CER integration modelling methodology", and Figure 12 of this report.

Figure 10. Solution Map focus in SAPN's Energy Transition modelling

To assess the impact of network solutions, SAPN uses a multiplier factor to increase the modelled hosting capacity. These values are derived from SAPN's experience, electrical models and before-and-after tests. The tool includes iterations to account for progressive group-level solutions (e.g; implemented at feeder or substation level). The solutions can fully or partially remediate the constraint.

SAPN has estimated the cost of the solutions with actual historical expenditure.

See Section "7. Selecting Constraint Remediations" of SAPN's "CER integration modelling methodology" for additional information.

Solution	Constraint Type
Line Drop Compensation (LDC)	Voltage
Voltage Regulator (VR)	Voltage
Tap	Voltage
Upgrade	Voltage & Thermal
Infill	Voltage & Thermal

Figure 11. Example of remediation solutions for hosting capacity constraints. Source: "CER integration modelling methodology"

3.5.2 Implemented recommendations

Within the Solution Map block, Blunomy considers the solution efficacy ratios as a crucial parameter that significantly impacts the result, and recommended SAPN to validate and fine-tune them. SAPN started implementing this recommendation and is still working on gathering empirical information on hosting capacity multipliers.

Implemented recommendations (fully or partially)	Materiality	Blunomy's comments
Align multiplier with empirical data (before and after)	● High materiality	SAPN performed five before/after tests to refine the efficacy of tapping distribution transformers. After the tests, SAPN reduced the multiplier from 300% to 220% increasing confidence in the assumptions used. The implementation of LDC in three substations is planned to generate data for future tool versions. For other solutions, empirical data can be progressively gathered when the interventions are planned in the network.

3.5.3 Outstanding improvements

Blunomy did not identify additional outstanding improvements beyond progressively improving the solution multipliers through empirical data gathering.

3.6 Solution evaluation review

3.6.1 Overview

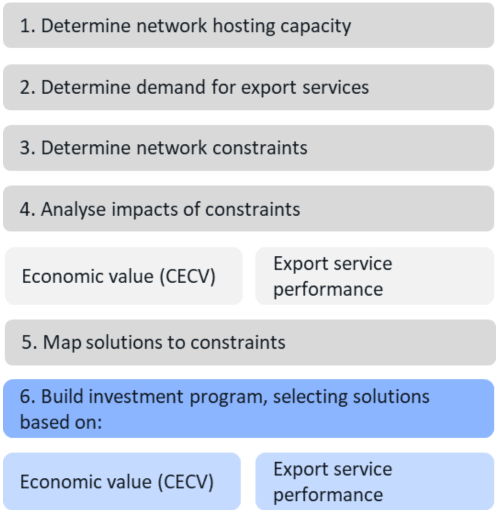


Figure 12. Solution evaluation focus in SAPN's Energy Transition modelling

SAPN selected a hybrid investment philosophy that includes both export service performance and economic outcomes in the prioritisation algorithm.

Available solutions to achieve an export service performance target are prioritised by selecting the most economical options (CECV).

Blunomy identified potential improvements in the cost-benefit analysis structure to allow for more robust solutions prioritisation. After the initial review, SAPN restructured its cost-benefit analysis approach, resulting in greater flexibility.

See Section "9. Creating an Investment Program" of SAPN's "CER integration modelling methodology" for additional information.

3.6.2 Implemented recommendations

Implemented recommendations (fully or partially)	Materiality	Blunomy's comments
- When an investment with progressive solutions is rejected in the cost-benefit analysis, roll back to analyse the interest of the first solution individually. This will still eliminate the second solution without individual analysis **- Improve the CBA structure to allow for individual solution analysis, conduct final NPV calculations from initial evaluations and allow for greater flexibility** **- Complementary KPI to analyse hybrid scenarios**		The current version of the cost-benefit analysis enables individual and grouped solution analysis, aligning with Blunomy's recommended approach. SAPN's model calculates the benefits of each solution (CECV/economic and export service performance) for every transformer with constraints over a 20-year period. By comparing the solution's benefits to the costs, SAPN can prioritize the final investment plan according to different objectives, including hybrid approaches. As presented by SAPN, the current model should be robust enough to carry out sensitivities and develop internal confidence in the results. Blunomy did not review the investment plan results.
Include Information about planned REPEX		The current version of the tool considers the planned REPEX investment as an input. The list of planned REPEX replacements is included before calculating hosting

		capacities, avoiding double counting or unnecessary investment provisions.
Include non-network solutions if pertinent		Additional SAPN workstreams generate benefits with non-network solutions. The LV Planning Engine uses the information of these workstreams as inputs: • As part of its assumptions for discretionary load, SAPN considers the gradual increase in Time of Use (ToU) tariff profiles, which are expected to alleviate some potential congestion. • Moreover, SAPN has modelled the impact of increasing network visibility and an anticipated rise in inverter compliance levels, enabling Volt-VAr response. • The model also includes the expected impact of SAPN's proposed demand flexibility program in increasing daytime load. SAPN indirectly considers non-network solutions by incorporating these inputs as base scenario. Blunomy suggests conducting a peer analysis to find potential successful additional non-network solutions that could be added to the tool.

Legend used for the recommendations:

Low materiality Medium or unknown materiality High materiality

3.6.3 Outstanding improvements

Blunomy did not identify additional outstanding improvements beyond progressively adding additional non-network solutions, if adapted. Blunomy did not review the coherence of the investment programs generated by SAPN.

4) Conclusions and next steps

The collaboration between Blunomy and SAPN has led to significant enhancements in the LV Planning Engine since March 2023. Over the last 11 months, SAPN has successfully implemented fully or partially 12 out of Blunomy's most material recommendations (out of 16), significantly bolstering confidence in the modelling approach.

Main outstanding improvements are linked to the hosting capacity modelling. Considering the data limitations, Blunomy believes that SAPN's current approach allows to correctly forecast network constraints and to prioritise solutions according to SAPN's objectives.

The LV Planning Engine, being a complex tool, necessitates a continuous improvement and a maintenance plan, particularly as additional smart meter data becomes available.

Blunomy recommends:

- Continuing hosting capacity assumptions refinement using additional smart meter data and reducing the dependency on categorical approaches.
- Continuing to conduct sensitivities and tests with additional smart meter data to increase confidence in the model.
- Gradually fine-tuning power flow assumptions (solar rooftop, electric vehicle, electric batteries, discretionary load, weather), to enhance alignment at the transformer level.
- Increasing non-network solutions in the LV Planning Engine if their business cases evolve in the regional context.
- Beyond this submission, the LV Planning Engine will serve for Network planning activities. This new application will generate additional requirements, to be addressed in further versions of the tool.

5) Appendix

The following Appendix presents Blunomy's understanding of the LV Planning Engine evolutions since March 2023. The information is based on four interviews conducted with SAPN's team in September/October 2023.

Legend used for the recommendations:

Low materiality · Medium or unknown materiality · High materiality

Improvement implemented · Partial implementation · No implementation

5.1 Power flow recommendations factsheets

Prioritise increase in PV on customers without existing PV installations

Initial recommendation (April 2023):

- Materiality: **Medium or unknown**
- Impact of inaction on investment plan: **Unknown**

Status and outstanding improvement (Oct. 2023):

- **Recommendation implemented?** No
- **Implementation description:** SAPN compares total PV uptake assumptions to AEMO statewide forecasts and uses postcode CER uptake forecasts as inputs. This ensures that potential saturation is considered at a postcode level.
  Postcode-to-transformer mapping assumes equal customer uptake without considering potential transformer level saturation.
- **Outstanding improvement**: Prioritise increase in PV on customers without existing PV installations.
- **Materiality of outstanding improvements:** Medium or unknown
- **Blunomy's comment:** SAPN did not include the recommendation in the 2025-30 submission version. The current calculation method may lead to discrepancies at the transformer level. SAPN shared that most of the transformers should have an even distribution of rooftop solar between customers and that most of the customers (~65%) do not have solar panel today. However, the magnitude of the potential impact on the overall investment envelope is unclear without conducting additional tests. The potential impact of the remaining improvement is considered minor to medium.

Additional questions for SAPN to determine the impact of the recommendation:

- **General power flow question: what is the accuracy of the current power flow model when compared to smart meter data (e.g. % difference between measured data and power model results)?**
- What is the average number of transformers by postcode?
- How many post-codes with multiple transformers have transformers that are already at high PV penetration levels (close to saturation compared to available roof space)?

Ensure consistency between PV uptake and load growth in new development areas

Initial recommendation (April 2023):

- Materiality: **Medium or unknown**
- Impact of inaction on investment plan: **Unknown**

Status and outstanding improvement (Oct. 2023):

- **Recommendation implemented?** Partially
- **Implementation description:** SAPN has substantially improved the alignment between solar rooftop and discretionary load.
  PV uptake assumptions at the state and post-code level align with AEMO's forecasts. In the current version of the tool, SAPN improved the discretionary load assumptions, aligning the state-level load growth assumptions to AEMO's forecasts as well.
  However, at the postcode/transformer level, there is still a non-alignment of PV uptake and discretionary load growth. SAPN will implement this in future versions of this tool by generating a new connections forecast.
- **Outstanding improvement**: Ensure consistency between PV uptake and load growth in new development areas at the transformer level.
- **Materiality of outstanding improvements:** Medium or unknown
- **Blunomy's comment:** SAPN improved the input data since Marche 2023 considerably, allowing for better post-code level projections.
  The current calculation method may lead to discrepancies at the transformer level. However, the magnitude of the potential impact to the overall investment envelope is unclear without conducting additional tests. The potential impact of the remaining improvement is considered minor to medium.

Additional questions for SAPN to determine the impact of the recommendation:

- How is the discretionary load upscaled at the post-code level? Is there a fixed factor?
- What is the expected PV uptake share coming from new connections at the state level?

Generate BESS profiles (auto consumption) matching solar profiles

Initial recommendation (April 2023):

- Materiality: **Low**
- Impact of inaction on investment plan: **Unknown**

Status and outstanding improvement (Oct. 2023):

- **Recommendation implemented?** No
- **Implementation description:** SAPN improved its initial BESS profiles to account for two different behaviours: solar shifting and VPP. These profiles are currently non-correlated with solar profile and their underlying weather conditions. The BESS profiles were constructed considering exclusively high-solar days to best match conditions with a higher probability of needing curtailment.
- **Outstanding improvement**: Generate BESS profiles (auto consumption) matching solar profiles.
- **Materiality of outstanding improvements:** Low
- **Blunomy's comment:** After Blunomy's initial review, SAPN added an additional BESS profile to correspond to solar shifting. However, the profiles are still not linked to the PV profile, which may cause discrepancies. The potential impact of the remaining improvement is considered minor.

Additional questions for SAPN to determine the impact of the recommendation:

- Does the PV profile in high-solar days correspond to curves observed in smart meter and BESS profile?
- Could you share a plot if the BESS and PV profiles?

Improve the granularity of PV profiles, by considering geographical irradiance data (satellite information available)

Initial recommendation (April 2023):

- Materiality: **Low**
- Impact of inaction on investment plan: **Overspend**

Status and outstanding improvement (Oct. 2023):

- **Recommendation implemented?** No
- **Implementation description:** SAPN utilises a single average PV profile, without adaptations depending on the location in South Australia.
- **Outstanding improvement**: Improve the granularity of PV profiles, by considering geographical irradiance data (satellite information available).
- **Materiality of outstanding improvements:** Low
- **Blunomy's comment:** Given the size of SAPN's territory, we suggest evaluating the necessity for additional PV profiles for different locations. For instance, regions with higher irradiation, given the uneven load distribution, could require different investment levels.
  SAPN shared that estimate irradiance difference in the region of around 10% by latitude and that most of the network is in the same band as Adelaide. The potential impact of the remaining improvements is believed to be minor.

Additional questions for SAPN to determine the impact of the recommendation:

- Are there important irradiation differences in SA's territory?

Possibility to increase the number of EV charging profiles, depending on the type of customers expected in the zone - Indicated as longer-term improvement (could be conducted after October 2023)

Initial recommendation (April 2023):

- Materiality: **Medium or unknown**
- Impact of inaction on investment plan: **Unknown**

Status and outstanding improvement (Oct. 2023):

- **Recommendation implemented?** Yes
- **Implementation description:** In the current version of the tool, SAPN modified the EV profiles to include Overnight, Solar Sponge and Peak charging curves linked to ToU (Time of Use) tariffs.
- **Outstanding improvement**: NA
- **Materiality of outstanding improvements:** NA

- **Blunomy's comment:** SAPN increased the number of EV charging profiles representing different behaviours, according to the LV Planning Engine team. To assess the potential improvement generated, SAPN should compare the % error of the power flow models to historical smart-meter data.

Additional questions for SAPN to determine the impact of the recommendation:

- How are the different profiles attributed to the customers in the model?
- What is the change/improvement in the % of error of power flow models compared with smart meter data, when using former EV profile assumptions against current ones?

If material, evaluate the possibility of increasing the number of consumer profiles (discretionary load) - Indicated as longer-term improvement (could be conducted after October 2023) ✓

Initial recommendation (April 2023):

- Materiality: **Medium or unknown**
- Impact of inaction on investment plan: **Unknown**

Status and outstanding improvement (Oct. 2023):

- **Recommendation implemented?** Yes
  Implementation description: SAPN has significantly evolved its load profile assumptions. The original profiles were based on past studies conducted in 2019 and showed theoretical behaviours for different sectors. These have been replaced with smart meter data-generated profiles, each with two versions: a low-orchestration/low-price-responsive version based on historical flat tariff and a high-orchestration/high-price-responsive version based on recent profiles for customers with ToU tariffs.
- **Outstanding improvement**: NA
- **Materiality of outstanding improvements:** NA
  Blunomy's comment: As we move towards 2030, the hypothesis for discretionary load will converge towards a majority of ToU tariffs. In future versions of the tool, SAPN will need to to determine if better describing nuances within ToU consumers is necessary.
  To assess the potential improvement generated, SAPN should compare the % error of the power flow models to historical smart-meter data.

Additional questions for SAPN to determine the impact of the recommendation:

- What is the change / improvement in the % of error of power flow models compared with smart meter data, when using former discretionary load assumptions against current ones?

Generate a different profile or performance assumption for customers with existing PV ✗

Initial recommendation (April 2023):

- Materiality: **Medium or unknown**
- Impact of inaction on investment plan: **Unknown**

Status and outstanding improvement (Oct. 2023):

- **Recommendation implemented?** No
- **Implementation description:** SAPN utilises a single average PV profile, based on typical production for new installations.
- **Outstanding improvement**: Generate a different profile assumption for customers with existing PV
- **Materiality of outstanding improvements:** Medium or unknown
- **Blunomy's comment:** When customers extend their PV installations to cover a wider surface, the new capacity will likely have a different PV profile. To determine if a new PV profile is necessary, Blunomy recommends calculating the share of new capacity that will fall under this case.The potential impact of this improvement in the short term is considered minor to medium.

Additional questions for SAPN to determine the impact of the recommendation:

- What is the saturation level of current customers on PV? What is the expected PV uptake coming from them?

Include future profile evolutions such as electrification - Indicated as longer-term improvement (could be conducted after October 2023)

Initial recommendation (April 2023):

- Materiality: **Medium or unknown**
- Impact of inaction on investment plan: **Unknown**

Status and outstanding improvement (Oct. 2023):

- **Recommendation implemented?** Partially
- **Implementation description:** SAPN's latest tool version includes additional new features, such as discretionary load considering electricity pricing response behaviours and electric hot water load management.
- **Outstanding improvement**: Consider additional electrification trends, such as heat pumps and gas switch, to reflect additional emerging trends in the discretionary load assumptions if pertinent.
- **Materiality of outstanding improvements:** Low
- **Blunomy's comment:** By compiling quantitative information of expected additional electrification trends, SAPN can verify the materiality.
  SAPN already considers electrification trends as part of their sensitivity options, with the AEMO Strong Electrification scenario. The potential impact of this improvement is considered minor.

Additional questions for SAPN to determine the impact of the recommendation:

- What electrification trends are not considered in the tool? How material are they in South Australia?

5.2 Constraint identification and valuation recommendations factsheets

Already planned: use hosting capacity values calculated with meter information (if material, include link to transformer size)

Refine categorical mapping of transformers hosting capacity

Initial recommendation (April 2023):

- Materiality: **High**
- Impact of inaction on investment plan: **Underspend**

Status and outstanding improvement (Oct. 2023):

- **Recommendation implemented?** Partially
- **Implementation description:** In March 2023, SAPN generated the hosting capacity assumptions with categorical power flow data from 2018, that divided the network into 15 transformer categories. The new LV Planning Engine relies on smart meter data for hosting capacity estimations.
  Since SAPN doesn't have access to complete smart meter data, the team has developed an alternative approach with different methods used depending on the data availability for each transformer:

  Method 1 – applied to transformers on which SAPN has at least five advanced meters voltage readings available covering at least one month*. The available readings must include at least one voltage value higher than 258V to be considered for Method 1. For this group of transformers, the hosting capacity is estimated as the modelled power flow with voltages of 258V. This method is applicable to less than 1% of the transformers.

  Method 2 – applied to transformers on which SAPN has at least five advanced meters voltage readings available covering at least one month*. This method estimates the hosting capacity with a linear regression between modelled power flow and voltage readings. This method is applicable to around 2% of the transformers.

  Method 2a – applied to the rest of the transformers with insufficient smart meter data. The hosting capacity is the average power flow calculated with Methods 1 and 2 for each of the 15 categories. This average category values, replace the 2018 modelled data. This method is applied to ~97% of the transformers.

  *SAPN conducted a targeted analysis to determine the minimum amount of smart meter data needed to reduce the results' variability.

- **Outstanding improvement**:
  Historical data available - Currently, the hosting capacity analysis relies on only one month's worth of voltage and power flow data, resulting in variations in the monthly estimated hosting capacities. To improve the assumptions' accuracy and comprehensiveness, Blunomy recommends gradually increasing the number of months of data used in methods 1 and 2 until leveraging one full year of data.

  For Method 1 - Current comparisons between modelled power flow and monitored data indicate a bias (average error) of approximately 10kW. An error distribution analysis can help perform post-modelling corrections.

For Method 2 - the target of the R-squared coefficient used by SAPN to accept a power flow model is 0.5 (analysing the strength of the relationship between modelled power flow and voltage readings). Blunomy recommends targeting 0.7 R-squared coefficients to ensure a substantial model fit.

For Method 3 - The 15 categories created in 2018 are still used to describe 97% of the network, despite SAPN observing high variability within a category. SAPN plans to build machine learning models to improve this approach, but this still needs to be implemented. Blunomy recommends reworking this approach as soon as possible.

- **Materiality of outstanding improvements:** Medium or unknown
- **Blunomy's comment:** Blunomy's initial review identified that one of the most significant elements to improve the robustness of SAPN's approach was to revise the hosting capacity assumptions.

  Since the first review in March 2023, SAPN has made significant improvements by switching to the use of smart meter observations, which has increased the credibility of the assumptions. However, the availability of data remains a limitation, which affects SAPN's capability to rely solely on smart meters.

  SAPN still uses a categorical approach with a unique hosting capacity per category for most of the transformers, due to data and time constraints. This approach generated uncaptured hosting capacity variability. Without additional information on actual hosting capacity values and on sensitivity results, Blunomy can not confirm the materiality of the outstanding improvement.

  SAPN's team is working on finding an acceptable balance between the costs of acquiring data and the robustness of hosting capacity assumptions.

Additional questions for SAPN to determine the impact of the recommendation:

- Which categories of transformers face more constraints (require more investment in the final plan)?
- What is the variability in hosting capacities seen in Method 1 and Method 2 for these categories?
- What would be the impact in the investment plan of adjusting the hosting capacity for these categories to other values within the range seen in Method 1 and 2 results (targeted sensitivity analysis)?

5.3 Solution map recommendations factsheets

Align multiplier with empirical data (before and after) ✔ ●

Initial recommendation (April 2023):

- Materiality: **High**
- Impact of inaction on investment plan: **Underspend**

Status and outstanding improvement (Oct. 2023):

- **Recommendation implemented?** Yes
- **Implementation description:** SAPN employs a multiplier factor to upscale the hosting capacity in the model after implementing network solutions. The team has spent the last months validating and fine-tuning assumptions for tap and LDC solutions, conducting before-and-after tests on multiple transformers. The tests generated a month's worth of data. These tests provided valuable insights to adapt previous assumptions on the solution multipliers.
- **Outstanding improvement**: NA
- **Materiality of outstanding improvements:** NA
- **Blunomy's comment:** SAPN performed five tests to validate the efficacy of one main solution, tap, which can be tested with limited costs. This increased confidence in the multiplier data.

For other solutions, empirical data can be progressively gathered when the interventions are planned in the network.

Additional questions for SAPN to determine the impact of the recommendation:

- How many transformers were used for tapping and LDC tests?

5.4 Solution evaluation recommendations factsheets

When an investment with progressive solutions is rejected in WB4, roll back to analyse the interest of the first solution individually. This will still eliminate the second solution without individual analysis

Priority to be discussed internally - Improve the CBA structure to allow for individual solution analysis, conduct final NPV calculations from initial evaluations and allow for greater flexibility

Initial recommendation (April 2023):

- Materiality: **High**
- Impact of inaction on investment plan: **Overspend**

Status and outstanding improvement (Oct. 2023):

- **Recommendation implemented?** Yes
  Implementation description: SAPN chose to an investment philosophy that prioritises the Level of Service (LoS) outcomes over pure economic benefits maximisation. This aims to ensure an acceptable service quality, as discussed with its customers and the AER.
  SAPN would like to achieve 95% of day time without curtailment for at least 95% of its customers as Level of Service. The available solutions to achieve this target are prioritised by selecting the most economical options considering the CECV method proposed by the AER's guidelines.
  This prioritisation method generates a hybrid approach with Level of Service as the primary goal. The assessment of this philosophy is not included in the scope of this analysis.
  Regarding the cost benefit analysis, this analysis focuses on the modelling decisions. The original tool needed more flexibility to analyse solutions individually, potentially leading to overinvestment by grouping solutions without prior individual analysis.
  After the initial review, SAPN restructured of its cost-benefit analysis approach, resulting in greater flexibility. The model developed calculates the benefits of each solution (CECV/economic and Level of Service) for every transformer to alleviate a constraint before calculating the economic and level of service benefits generated over a 20-year period. By comparing the benefits of the individual solutions to the costs, SAPN can prioritize the final investment plan according to different objectives, including its selected LoS approach. As presented by SAPN, the current model allows to assess flexibly all potential solutions with different objectives.
- **Outstanding improvement**: NA
- **Materiality of outstanding improvements:** NA
  Blunomy's comment: The current CBA approach enables individual and grouped solution analysis, aligning with Blunomy's recommended approach for robust and flexible CBA. As presented by SAPN, the current model should be robust enough to carry out sensitivities and develop internal confidence in the results. Blunomy did not review the investment plan results to determine the materiality or pertinence of the "Level of Service philosophy" used instead of a purely economic investment approach.

Additional questions for SAPN to determine the impact of the recommendation:

- When comparing CECV and LoS scenarios, what is the difference between total investment?
- What share of investment overlap in the two plans?
- What are the LoS and economic KPIs for each scenario?

Include Information about planned REPEX

Initial recommendation (April 2023):

- Materiality: **Medium or unknown**
- Impact of inaction on investment plan: **Overspend**

Status and outstanding improvement (Oct. 2023):

- **Recommendation implemented?** Yes
- **Implementation description:** The current version of the tool considers the planned REPEX investment as an input. The list of network evolutions is included before calculating hosting capacities, avoiding double counting or unnecessary investment provisions.
- **Outstanding improvement**: NA
- **Materiality of outstanding improvements:** NA
- **Blunomy's comment:** SAPN's current tool version avoids double counting by including already planned REPEX and updating the hosting capacity in the net power flow projections when pertinent.

Additional questions for SAPN to determine the impact of the recommendation:

- NA

Include non-network solutions if pertinent

Initial recommendation (April 2023):

- Materiality: **Medium or unknown**
- Impact of inaction on investment plan: **Unknown**

Status and outstanding improvement (Oct. 2023):

- **Recommendation implemented?** Partially
- **Implementation description:** Additional SAPN workstreams generate benefits with non-network solutions. The LV Planning Engine uses the information of these workstreams as inputs:
    - As part of its assumptions for discretionary load, SAPN considers the gradual increase in Time of Use (ToU) tariff profiles, which are expected to alleviate some potential congestion.
    - Moreover, SAPN has modelled the impact of increasing network visibility and an anticipated rise in inverter compliance levels, enabling Volt-VAr response.
    - The model also includes the expected impact of SAPN's proposed demand flexibility program in increasing daytime load.

  SAPN indirectly considers non-network solutions by incorporating these inputs as base scenario. Blunomy suggests conducting a peer analysis to find potential successful additional non-network solutions that could be added to the tool

- **Outstanding improvement:** If further analysis shows that solutions such as communal batteries become economically feasible, these solutions should be included in the evaluation process.
- **Materiality of outstanding improvements:** Medium or unknown
- **Blunomy's comment:** SAPN is considering as inputs the impact of additional non-network solutions on the LV Planning Engine. Blunomy suggests conducting a peer analysis to find potential successful non-network solutions that could be added to the tool.

- What is the expected economic performance of the ToU and CER compliance projects when estimating the CECV benefits?
- How do they compare to the LV engine's investment plan's performance?

Complementary KPI to analyse hybrid scenarios

Initial recommendation (April 2023):

- Materiality: **Medium or unknown**
- Impact of inaction on investment plan: **Unknown**

Status and outstanding improvement (Oct. 2023):

- **Recommendation implemented?** Partially
- **Implementation description:** After the engagement with Blunomy, SAPN restructured the entire cost-benefit analysis approach, allowing greater flexibility to calculate economic or Level of Service KPIs for different scenarios.
- **Outstanding improvement**: NA
- **Materiality of outstanding improvements:** NA
- **Blunomy's comment:** The assessment of SAPN investment philosophy is not included in the scope of this analysis. The current CBA approach allows for greater flexibility and would allow to conduct hybrid approaches if selected by SAPN.

Additional questions for SAPN to determine the impact of the recommendation:

- NA

Paris

London

Singapore

Hong Kong

Melbourne

Sydney