Optimising Electric Bus Fleet Charging

Abstract

This project investigates using optimisation methods to minimise the maximum power used while charging a fleet of electric busses (EB).

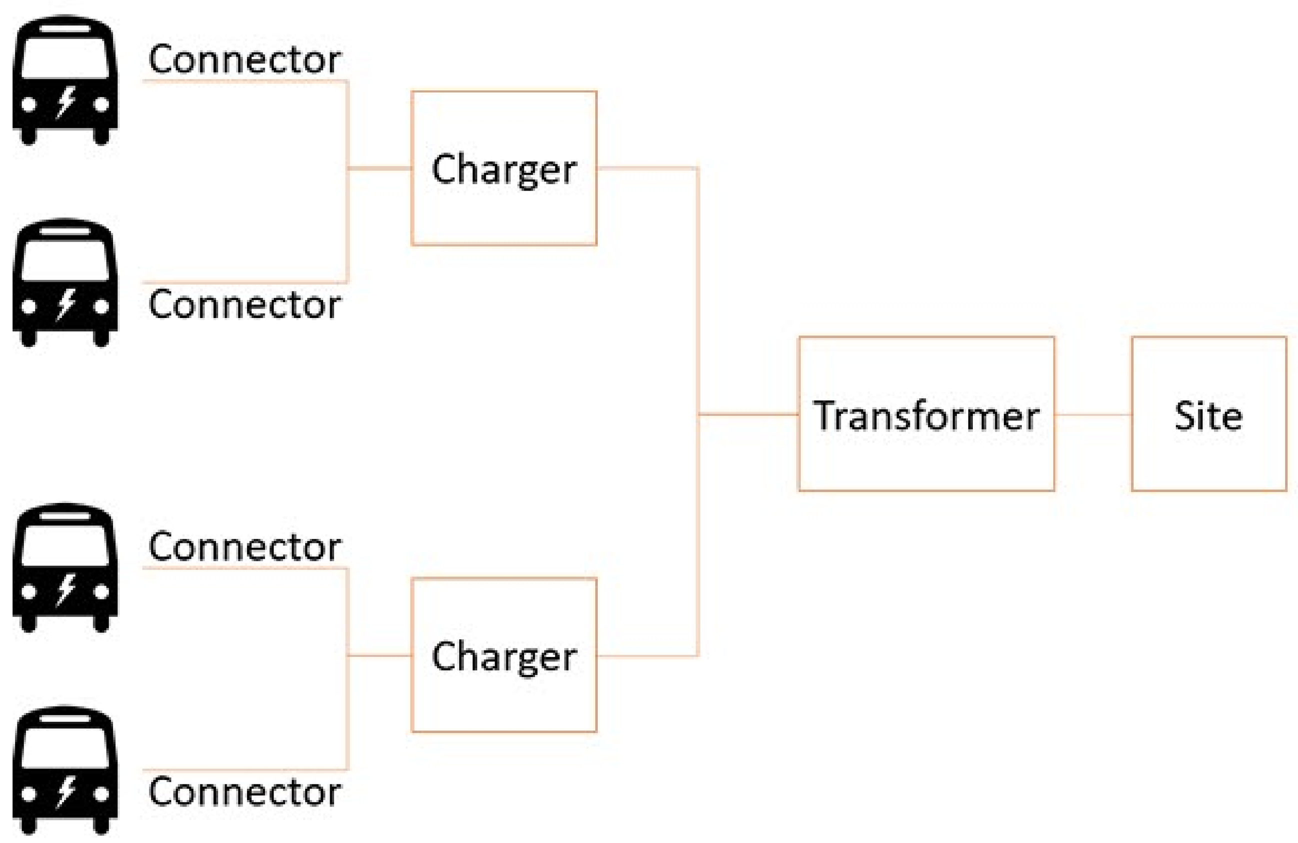
- The optimisation model is a mixed integer program (MIP) with a single objective.
- The results from the optimisation model show a significant improvement over an uncontrolled approach of charging at the maximum rate as soon as possible. The (connector) charging profiles, State of Charge (SoC) profiles and Total Power Usage comparing the two are shown on the right.
- For a small station with 10 busses, the peak usage reduced from 250kW to 100kW. This would save approximately $800 a month in demand charges for bus charging stations in Wellington.
- The transformer in the uncontrolled situation exceeds its maximum rating and would be damaged. The optimised solution prevents this from occurring.

Problem

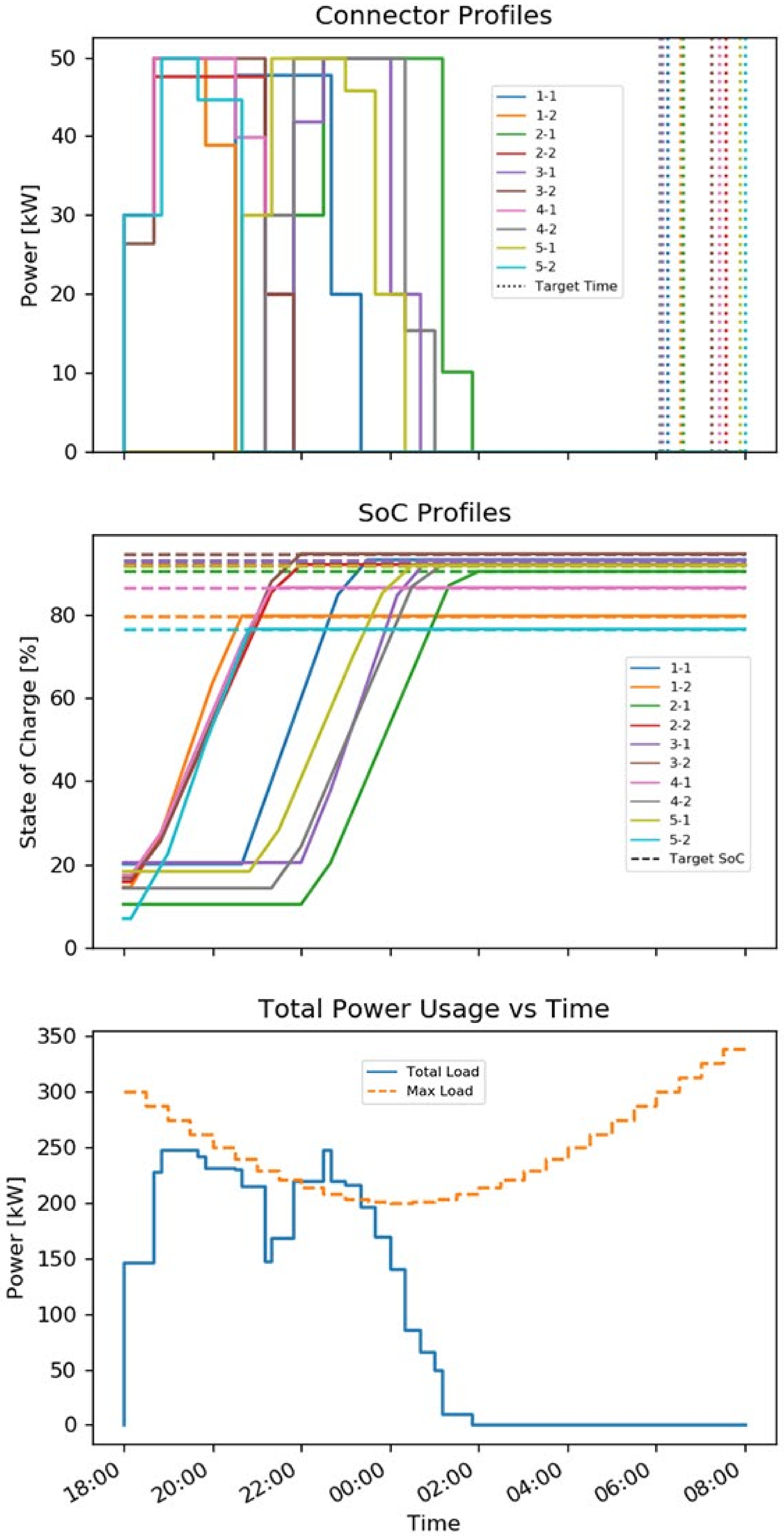
EVisi is a company that provide electric vehicle management systems and is interested in optimising EB fleet charging to reduce operational costs, in particular demand cost.

- Demand cost is calculated using the maximum total usage over a month.
- Each EB has an initial SoC, a target SoC and a target time to complete by.
- When an EB arrives, it is connected to a charger through a connector. Chargers can have multiple connectors, most have two.
- Most sites have a single on-site transformer which all chargers are connected to.

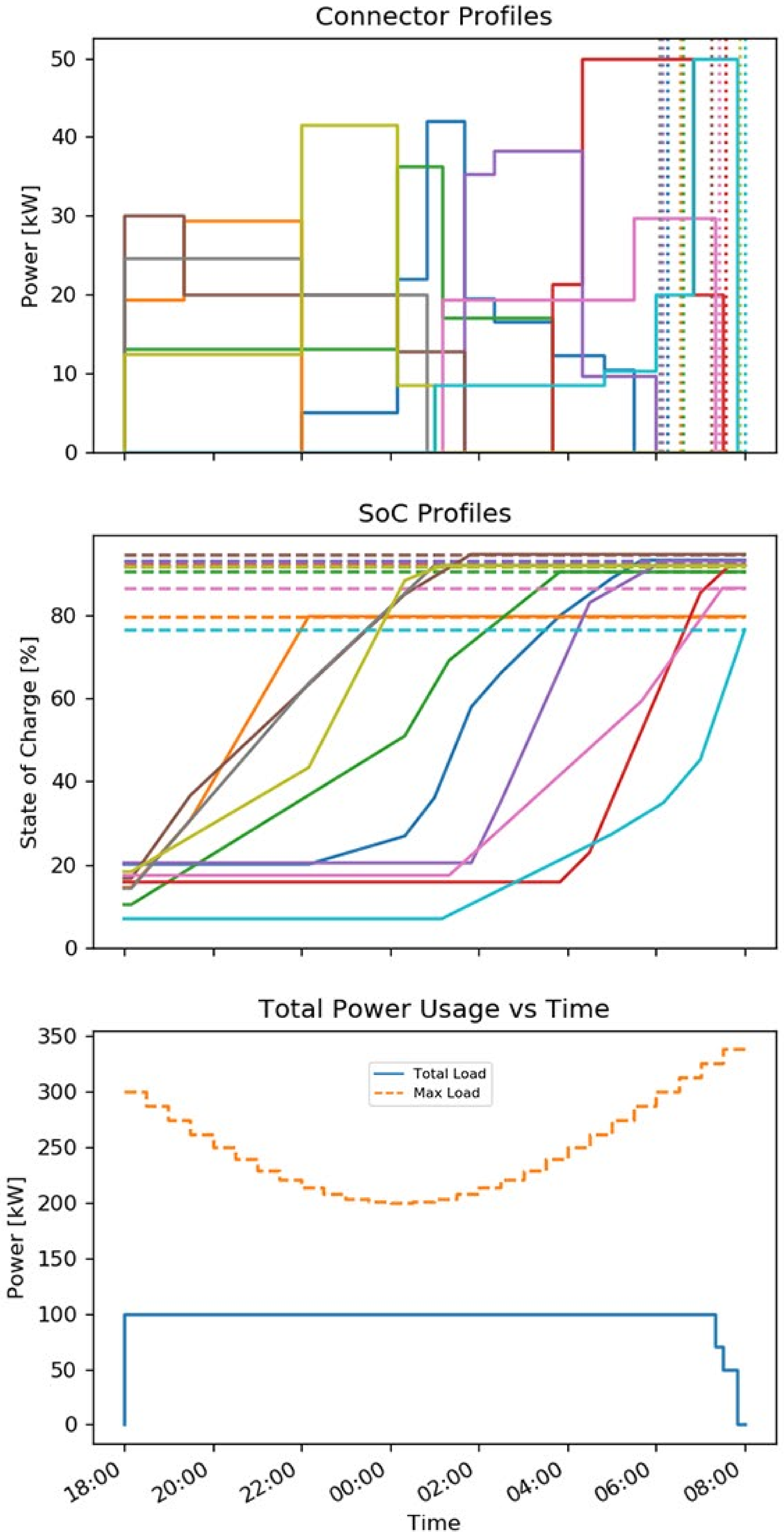
This structure is illustrated below.



Uncontrolled



Optimised



Acknowledgements

This research was funded partly by EVisi.
Research conducted by Colin Watanabe.
Supervised by Michael O' Sullivan.
Managed by Chris Olson.

EVisi

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

ENGINEERING
DEPARTMENT OF ENGINEERING SCIENCE

Optimisation Model

The model is a MIP that takes a discretised time approach; we divide up time for decisions to be made, typically 10-minute intervals.

- The main decision variable is the amount of power to supply through each connector in each time slot.
- The objective is to minimise the maximum power used over all time periods of charging.
- There are many constraints in the model. Some of the key constraints which reflect real world limitations include:
  - Chargers have a lower maximum power when the battery is nearly empty or nearly charged. This is to prevent damage to the battery.
  - Chargers should not rapidly change the power supplied to the battery.
  - Charging profiles should not have too many peaks, i.e. limit the number of ups and downs.
  - Most chargers can only charge through one connector at a time.

System Architecture

An important part of the research was designing how data will be sent and received between the optimiser and EVisi's existing management system.

- Data is received from the vehicles once they are plugged in through EVisi's system. This is then sent into an SQS queue for the optimiser.
- The optimiser is hosted on Amazon Web Services (AWS) as an AWS Lambda function. Lambda allows for serverless on-demand cloud-computing.
- The result is then sent as a JSON string to a HTTP endpoint defined in the input file. This HTTP endpoint will be linked to EVisi.
- This result is then processed and delivered to chargers through EVisi's system.

This structure is illustrated below.