NHP

Sharing the Load

Load management systems for charging electric vehicles in commercial and residential buildings

SMART DISTRIBUTION

2019 was a record year for Electric Vehicles (EVs) globally, with EVs making up around 3% of total new passenger car sales in the world.


electric

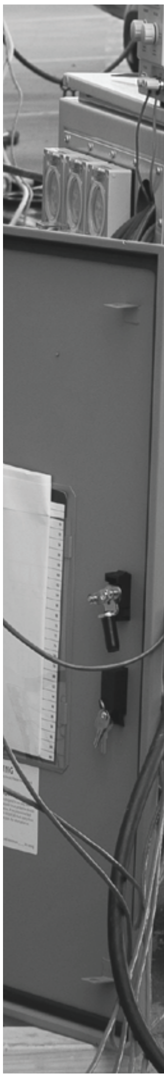
Australia has been relatively slow in taking up electric cars to date, but it's coming.

Forecasting from the Australian Energy Market Operator indicates that within 10 years, EVs are likely to make up a substantial proportion of new vehicles supplied into the Australian market, and that within 20 years that will be approximately half of all cars on the roads.

The key benefits of shifting to EVs are clear – they are cheaper to run and maintain, they don't contribute to air pollution, they help to reduce dependence on oil imports, and they provide a pathway to reduction in carbon emissions.

Given the constraints of Australia's existing electrical infrastructure design, for the EV revolution to happen we must manage how, where and when EVs are recharged, in order to avoid costly electrical upgrades.

In residential complexes, workplaces and commercial buildings, some smart scheduling will be required. Rather than letting everyone start charging at the same time, which would require a much bigger switchboard and network connection, a control system will manage the charging to ensure that everyone starts the next day with a full battery in their car, without putting any undue strain on the electrical supply.

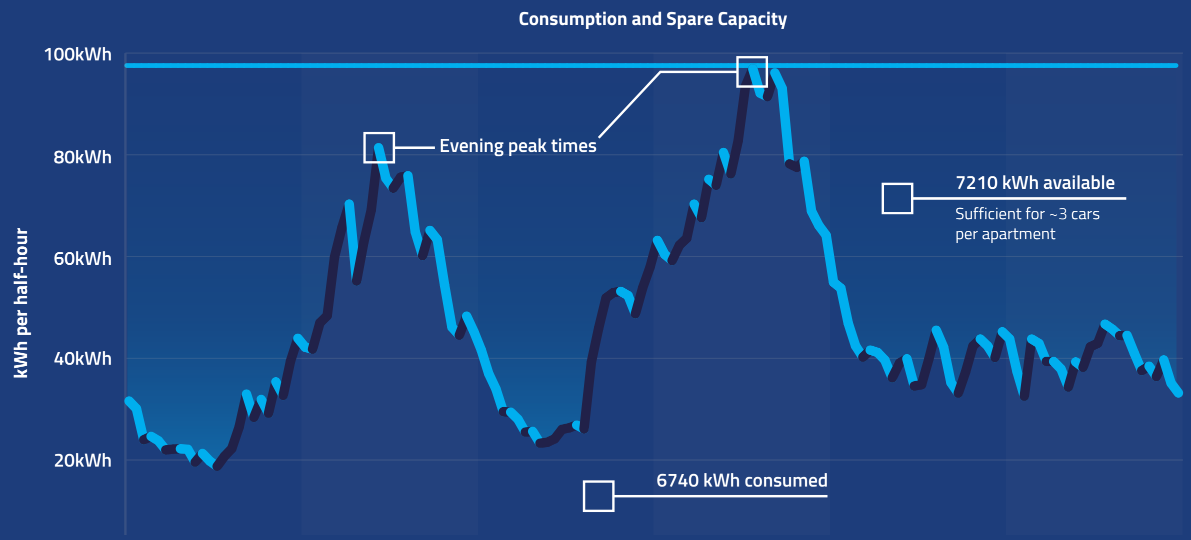


NHP recently undertook development and demonstration of a solution of this nature at our Laverton national manufacturing facility, in conjunction with car manufacturers, vehicle owners' associations and a electricity network service provider. Our customers in the electrical contracting community can now easily roll out load managed EV charging solutions to apartment complexes, workplaces, and commercial buildings.

How much capacity is available overnight?

In apartment complexes in Australia, peak energy usage typically occurs in the afternoons and early evenings of very hot or very cold days, when high power levels are required for cooling or heating. Generally, the switchgear and upstream connection to an apartment complex is equipped to support about an average of 3kW simultaneously per dwelling.

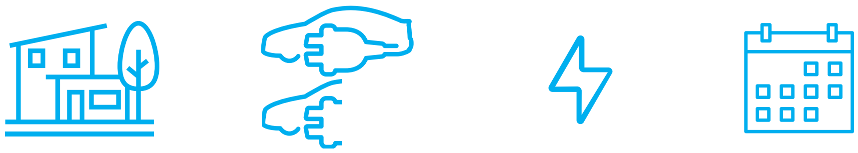
If everyone starts charging their cars at one time, this capacity won't be enough. Happily, analysis of apartment complex energy usage data tells us that even during the highest demand periods, there's lots of spare capacity overnight, when most electrical appliances are either switched off or running at low levels.



This chart shows a three-day period of electrical energy use in a typical apartment complex of 82 dwellings in Melbourne between 27-29 January 2018. The temperature peaked at 40°C on the 28 January, with an overnight low of 30°C. Being a Sunday, lots of people were at home with the air-conditioning turned up, staying out of the heat. It was a particularly challenging day for the electrical networks, being the highest three-day consumption period in the building over a four-year period.

The vertical axis is kWh consumed per half hour interval. At peak, the building total electrical load was a touch under 100kWh per half hour, or 200kW.

We know that on average, electric car drivers will consume about 10kWh per day, to cover the typical average Australian driving behaviour of 40 kilometres driven per day. We also know that in a typical apartment complex, there's likely to be at most 1.5 cars per dwelling on average. So, if we're looking towards a future where almost every car will be electric, in an apartment complex of 82 dwellings over three days we'll be looking at:



82 Dwellings × **1.5** Cars Per Dwelling × **10kWh** Per Car Per Day × **3** Days = **3,690kWh**

Figure 1: *Calculating capacity for vehicle charging in a typical apartment complex.*

If we consider the capacity of the building to serve additional loads such as EV charging, the goal is to stay under the actual peak demand level, so that the existing upstream connection doesn't need to be made any larger, and to avoid adding stress to the grid at times of peak demand. This means that the blue shaded area between the actual consumption and the peak interval consumtion on the chart shows the energy potentially available for supporting EV charging.

In this example, this area amounts to 7,210kWh, most of which is available between 9pm and 7am when it can be expected that most vehicles will be parked in the complex overnight. This is about twice as much capacity as will be needed in a future where almost every passenger vehicle based in this apartment complex is electric, and every driver may be looking to source almost all their vehicle recharging at home.

System Architecture

While Figure 1 above established that there is enough capacity to support a 100% transition to EVs in typical apartment complexes provided the recharging is scheduled, Figure 2 represents the architecture for a system that will achieve this.

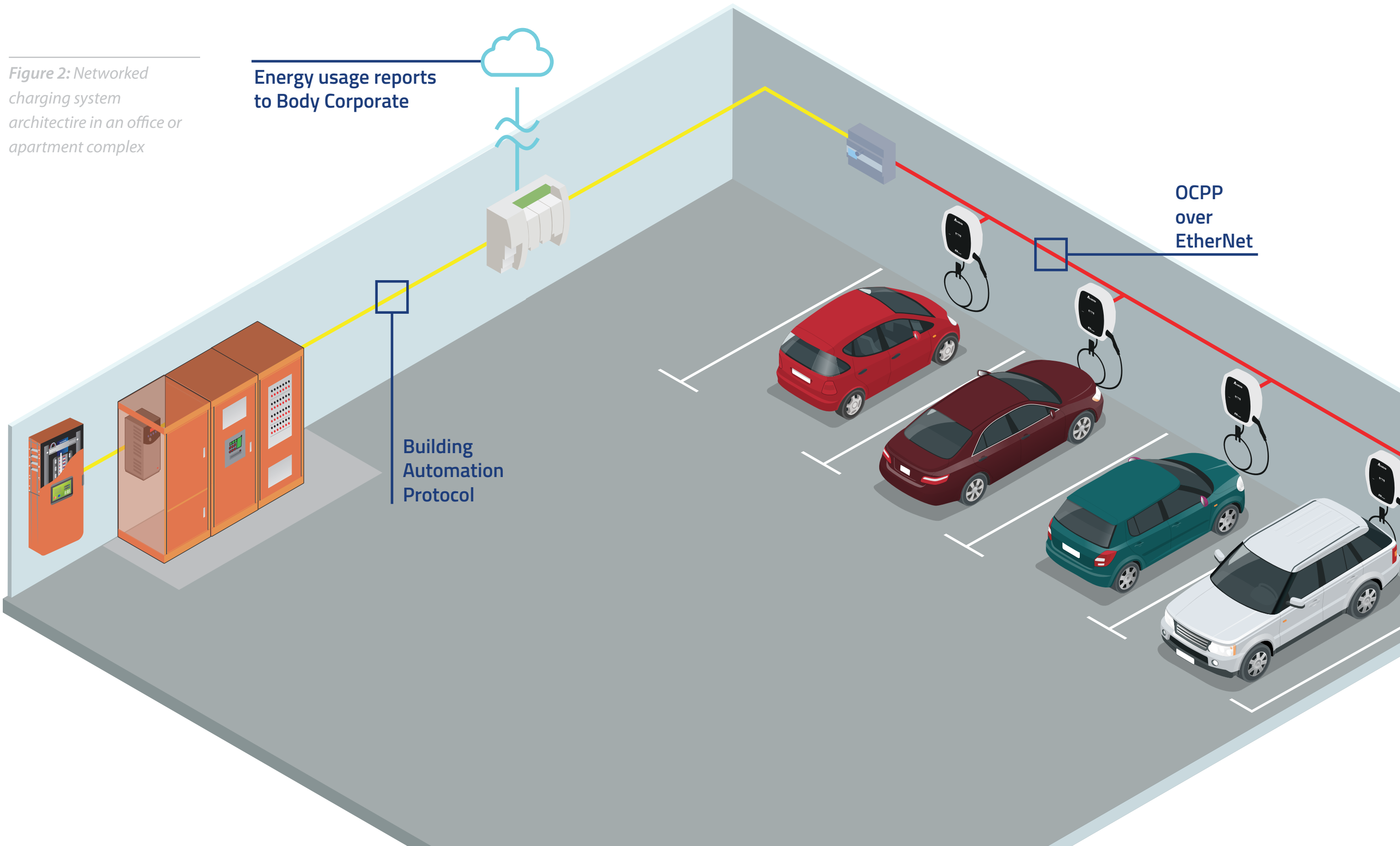


Figure 2: Networked charging system architectire in an office or apartment complex

The EV chargers (shown at the lower right of the diagram) are connected via Ethernet (on the OCPP protocol) to a communications gateway (shown at the lower left of the diagram).

This communications gateway is connected via a building automation network (typically Modbus TCP/IP) to a control system, which can be a Programmable Logic Controller (PLC), Building Management System (BMS) or equivalent. In NHP's development work, we've used an industry standard Rockwell Automation PLC and can provide sample code for this platform, but a wide range of different products and systems can be used here.

The building automation network can also pick up data from other assets in the building such as the main circuit breakers, as well as large assets such as central heating and cooling equipment. The main data point that it will generally need to pick up is the main incoming electrical supply, so that the control system can determine the minute-to-minute spare electrical capacity in the building.

The control system is equipped to export energy usage data to the body corporate or strata manager, to enable tracking and reporting of which vehicle charger is using energy and when. It is expected that the vehicle chargers will usually be supplied by common property power, and that in most cases they'll be installed in dedicated car parking spaces. While energy supplied to EVs has yet to be closely fiscally regulated in the same way that energy supply to premises is, the body corporate will still require a method to ensure that the cost of the energy supplied is fairly passed on, which will start with access to the data.

This data access can be achieved in a variety of ways:

- a simple display in the car park that can be manually read on site as required;
- a regularly scheduled email to the strata manager with an attached Excel file showing usage per charger; or
- a software-as-a-service style cloud-based platform that authorized parties can log in to.

How does it work?

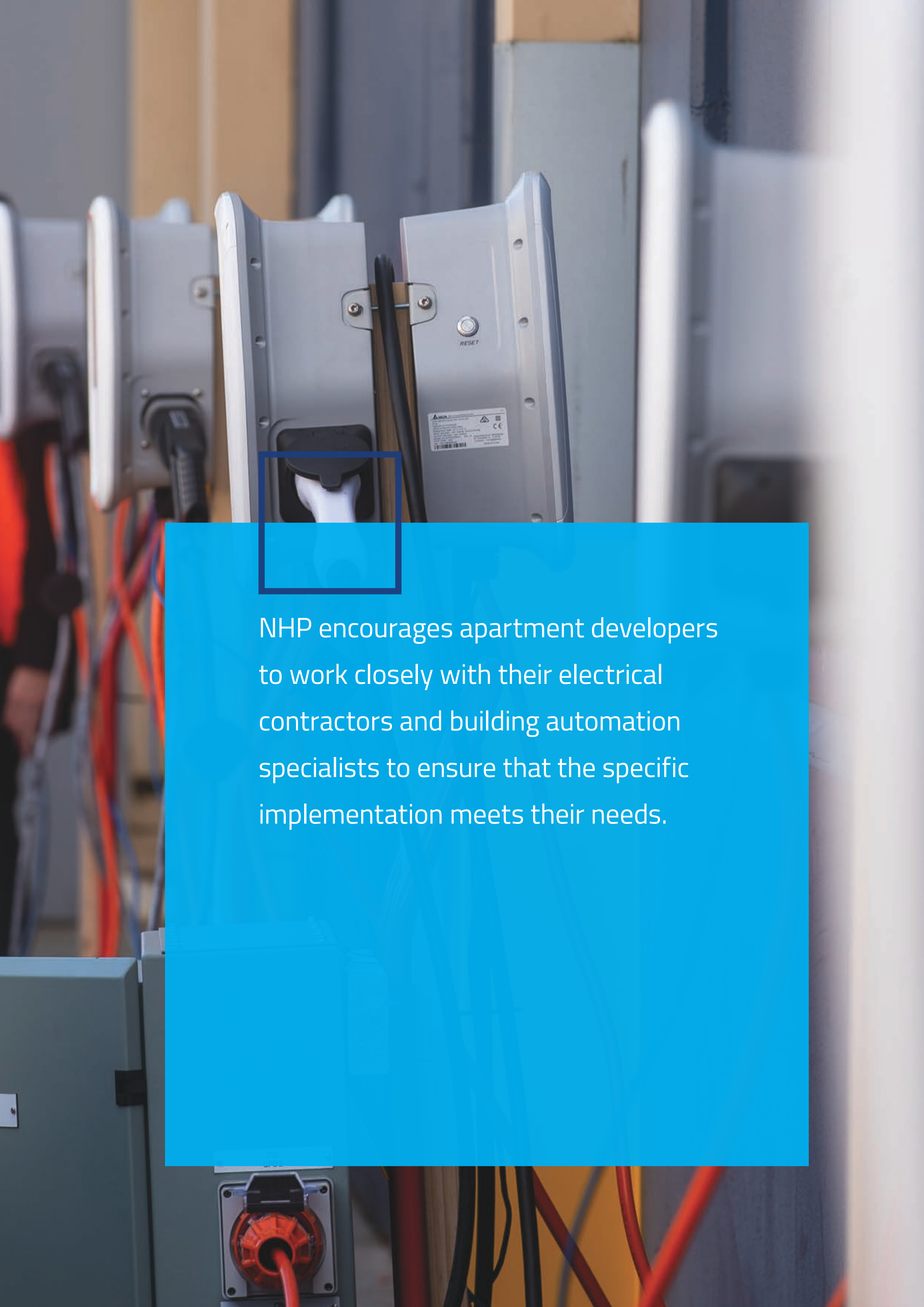
In an apartment complex, each site is going to have its own unique requirements. There might be visitor spaces or a penthouse apartment that always gets priority, or there might be rooftop solar panels that the residents want to take advantage of during the day. For this reason, NHP have not developed a rigid 'one-size-fits-all' approach, but instead a tested architecture to enable many different control strategies.

The communications gateway gives access to several specific data points in each charger, allowing the control system to be designed to achieve the following:

- Read real-time current (Amps) and energy (kWh) data from multiple points, including the EV chargers under management and energy meters at other locations in the building.
- Determine the appropriate behaviour for each EV charger based on known building parameters and real time current and energy data collected, with the goals of:
  - mitigating collective impact of EV charging equipment on building peak demand;
  - avoiding overloading of any elements of the electrical reticulation system in the building;
  - ensuring to the extent possible that every EV connected is fully recharged overnight;
  - facilitating participation in demand response arrangements.
- Enact this behaviour on the EV chargers under management.
- Monitor the behaviour of the EV chargers under management, to ensure that the system is performing as intended.
- Maintain in an appropriate, accessible data structure of the cumulative energy used by each EV charger, for potential use in other systems and for reporting to the body corporate.
- Scale to include additional EV chargers as they are added at the site over time, up to the total number of car parking spaces in the premises.

At its simplest level, the logic in the control system can be explained in a very basic flowchart:

Figure 3: *Logic for a generic control system*



NHP encourages apartment developers to work closely with their electrical contractors and building automation specialists to ensure that the specific implementation meets their needs.

Some notes on workplaces and commercial premises

To this point, we have focussed mainly on apartment complexes, where the behaviour of drivers is generally to come home in the evening, leave the vehicle in their designated car parking space for 10-12 hours or more, and then leave in the morning. This suits the needs of EVs very well, because the apartment has large amounts of spare capacity overnight, and the vehicles are parked there at that time while their owners sleep.

Workplaces present a different challenge. While the same system architecture will work from a load management standpoint, the cars are typically at the workplace between 9am and 5pm, which is when the building is generally using its existing electrical supply. On a particularly hot or cold day, there's unlikely to be as much spare capacity at a workplace during the day as there is at an apartment complex overnight.

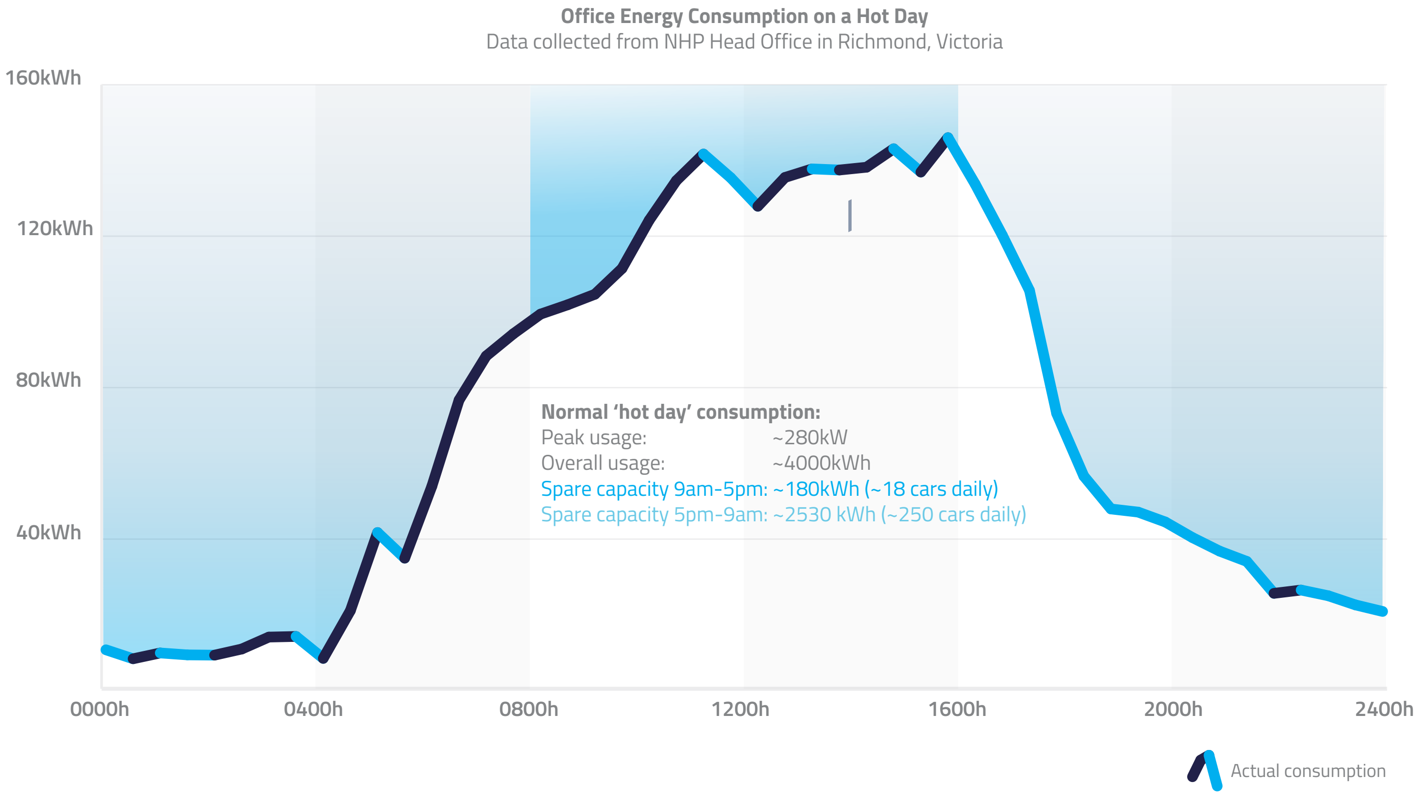
As a modelled example of this, we can consider NHP's head office building in Melbourne, on a day of high demand. This is a building where ~150 staff routinely drive to work and park their cars in the on-site car park for the day.

What we can see here is that the load that peaks at 280kW, and is consistently above 200kW between 9am and 5pm. Over the work day, on a hot day the energy available (shaded in green in Figure 3) amounts to around 180 kWh

The result is that if we were to try to supply every vehicle at the premises with 10kWh of energy on a hot day, we would fall short. Assuming a managed approach to charging to ensure that the existing peak demand is not exceeded, the 180 kWh available on a hot day will make it feasible to recharge the daily driving needs of 18 EVs. By contrast, if we were considering pool vehicles that were parked on site overnight, there would be sufficient capacity to support the daily needs of approximately 250 vehicles.

This is not to say that daytime work place charging isn't useful, only that it needs more site-specific consideration than apartment complexes. It may not ultimately prove cost effective to service all drivers at a particular workplace this way, but as the example above shows, there's certainly room to accommodate the first 10%-15% in a typical workplace, which will take us through to 2030 or thereabouts based on forecasting of EV uptake from the Australian Energy Market Operator.

Commercial premises and workplaces come in many different shapes and sizes, and with many different energy usage profiles. Rather than presenting an exhaustive treatment here, we'd encourage consultation, starting with the existing energy usage profile at the site and some clarity around how many vehicles would expect to charge there at what time of day.



Standards and codes

The wiring rules (AS/NZS3000:2018) have recently incorporated informative guidance for EV charging, with a baseline assumption in the methods for calculating peak demand that charging will happen on a given site simultaneously and in an unmanaged fashion. This leads to a conclusion that vehicle charging will create an additional large load co-incident with the existing peak demand in a building such as an apartment complex, which significantly adds to the cost of switchboard design and network connection for new builds.

There is a methodology in AS/NZS3000:2018 which is intended to be used in cases such as this one, where the load is of a known duty cycle. For Australian installations, rather than using the calculation method for establishing maximum demand (clause 2.2.2.a), for large scale EV charging installations, NHP recommends the use of the assessment method for establishing maximum demand (clause 2.2.2.b.i). This method will require some additional work on the part of the system designer but will significantly reduce the requirements for increased switchboard and network connection size that would arise from using the calculation method.

Under the assessment method, the underpinning assumption of the load management system in the context of an apartment complex is that the EV charging will not contribute to maximum demand. On a hot weekday evening when everyone arrives home from work and plugs their vehicles in, the load management system will ensure that vehicles do not draw energy until such time as there is spare capacity. As described previously, there is plenty of spare capacity overnight, so that everyone can be confident that there will be enough recharging overnight to get them to work the next day. For the driver who really needs a fast recharge 'right now', their apartment charger isn't the right piece of equipment – they can stop at a fast charger in their neighbourhood instead, in much the same way as we use petrol stations today.

At time of writing, the National Construction Code has no requirements to make new apartment complexes EV ready, but a range of industry stakeholders including NHP are working on this. The goal of this work is to ensure that while we don't need an EV charger in every apartment car parking space today, with a little bit of preparation it can be made very easy to cost effectively install them in future, when they are very likely to be required. Without that little bit of preparation, retrofitting EV charging to apartment complexes can be commercially and procedurally very challenging.

Want to know more?

NHP have published our system user manual, parts lists, source code and other documentation around this solution at **nhp.com.au/Power-Distribution/Electric-Vehicle-Chargers**

To download EV dynamic load management software, go to nhp.com.au/Page/Electric-Vehicle-Chargers.

To the extent possible, we've made this development as open and as transparent as we can. It's an emergent area which offers long term benefits to the entire electrical industry, as well as the country as whole. If you're considering an application of this type, please give us a call on **1300 647 647** - we'll be happy to help.

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