Electric Car Lies

By Paul Matthews 2020

Now lets get something straight here. I'm an electrician. Nothing would please me more than to see a transition away from the internal combustion engine and towards universal electric transport.

However just as my paper on *"power networks for dummies"* exposed the impossibility of replacing coal fired power plants with renewable generation, this paper will spell out the facts surrounding electric cars and how much (or how little) they can offer in regards to "greening the planet".

First, we're going to have to bring you up to speed with a few issues. Unfortunately this time we're going to have to get the calculator out. I promise to keep the maths and numbers as simple as possible.

Australian Electrical Wiring

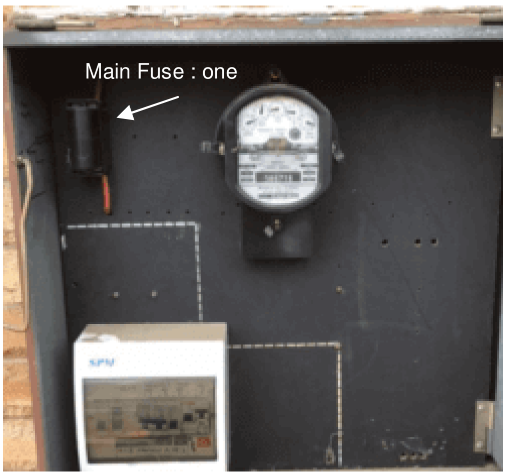
Before we even have a look at electric cars, we must first consider available infrastructure we have to fuel them. Already, Australia is internationally miles ahead of at least half the world when it comes to the strength of our household power networks. This is principally due to our higher distribution voltage : 240/415v.

In Australia, our premises (homes and businesses) use electricity for more and wider applications than most overseas countries do. A very large proportion of our homes are "all electric." As a result, our domestic networks have been designed around the higher energy density and lower diversity that comes with using electricity for things like water and space heating. Overseas homes generally use older, fossil fuel based options for these tasks such as coal, oil and natural gas.

Not withstanding the diminishing number of older and un renovated premises built before the wiring rules of 1976 were adopted, the lions share of our modern homes and businesses in Australia today are supplied with either a **230 volt, 80 Amp single phase supply** or a **415 volt, three phase 63 Amp supply**. Compared with overseas, a *disproportionately* ***large number of Australian homes have a three phase supply*** connected. Overseas, this is practically unheard of. Virtually impossible in 120v countries.

What do all these numbers mean?

The figures above denote the **maximum amount of electricity that can be drawn by a premises** before the main fuse blows. Ignoring things like power factor (which we'll assume as being ideal at 1.0 so as to not confuse you too much), the **absolute *maximum amount of energy that can be supplied through these connections at any one time* is as follows**;



Single phase 230v, 80A supply.
Max 18.4kW (kilowatts).

Three phase 230v, 63A supply.
Max 43.47kW (kilowatts).

Distribution system diversity

200kW distribution transformer
typically feeds 15-30 houses

Before we delve further inside your house, first lets have a look at what's going on outside in the street. Regardless of whether your area is serviced by overhead or underground power, every block or around 60 houses you'll find a *distribution transformer* which supplies 230/415v from the local 11kV networks. In suburban Australia, these are usually of a capacity around **400kW.**

Now if we consider that each of these *sixty single phase houses* are able to pull a maximum of *18.4kW from the supply*, we find that transformer really should be ***1104kW***—not a mere *400kW.* In fact if we consider that at least half of those houses probably have three phase supplies connected, this maximum adds up to a **whopping *1806kW.*** We haven't even considered business premises yet!

The reason our lights stay on without the distribution transformer exploding, is because of ***diversity.*** This works on the assumption that **all premises are not going to be pulling the maximum amount of power out of the network all at the same time.**

Even on the hottest day of the year when air conditioning demand is maxed out, there will probably be *at least one third of these houses standing empty* with demand at virtually zero. Of the remainder, the air conditioning load still represents only a fraction of the total power each house can potentially draw from the network.

So if we have **60 houses** (20 of them **empty**) and each of the other 40 houses running two large 4kW split air conditioners flat out on a 48 degree day, this still adds up to only *320kW.* Even in this demand peak situation, our *400kW distribution transformer is more than capable of providing electricity to all sixty houses*. The electricity distribution companies regularly monitor the demand on their distribution transformers by reading the "maximum demand indicators" attached to each transformer. If these MDI's routinely begin to show that a transformer is becoming overloaded, the company must then invest in a "network upgrade." This can either involve swapping the transformer out for a bigger one, or installing another transformer further down the road and dividing the sixty houses across the two.

Domestic loads, "peak" and "off peak"

Back in the middle of last century and well before rooftop solar was even a dream, the power companies had a dilemma. *The coal fired plants they use to supply energy to the network are very inefficient when they're not working at near full capacity.* Engineering wise, it's very difficult to "wind up" and "wind down" a large coal fired plant to meet the fluctuating demands of the network. A coal plant running at 40% load gobbles almost the same amount of coal as it does if it were running at 70% load.

Demand during the day and in to the evening was high. It would then taper off to very low at night, after 10pm when business was closed and everyone was asleep. The intelligent solution of the day was to take a look at existing loads on the network to see if it were possible to prevent them from drawing power at peak times.

In exchange for deep discounts given to customers, *"off peak electricity"* was born. Instead of installing small and cheap 80 litre or instant water heaters that sucked power whenever someone took a shower or used hot water, customers were encouraged to invest in larger, 400 litre tanks. Through use of a special network of relays, the "off peak" heaters would only be connected to the network at night though a separate meter, charged at around 35% of the usual day rate. The heaters would "charge up" with hot water at night, which could then be used throughout the following day.

With a typical load of 4.8kW per house, Australian “off peak” water heating networks are immense. There’s every reason to believe Australia became a world leader in this regard. Even today, it takes hundreds of megawatts of load off the network during the day and then applies it at night, in return for very low energy costs to the consumer. In most homes the 4.8kW “off peak” water heater is easily the biggest load in the house. It also operates for the longest time - typically 5~8 hours to heat a cold tank.

Considering our “sixty houses” example above, every night an *additional 288kW of load is going to be connected to our 400kW distribution transformer at 10pm.* Multiply this effect over whole suburbs and cities… the effect of connecting hundreds of thousands of water heaters to the national network at night is easily recognisable on national electricity demand graphs today, especially in Winter.

Can you see a pattern developing here? A collusion against our electric car?? Hmm…. We’ll come back to that later.

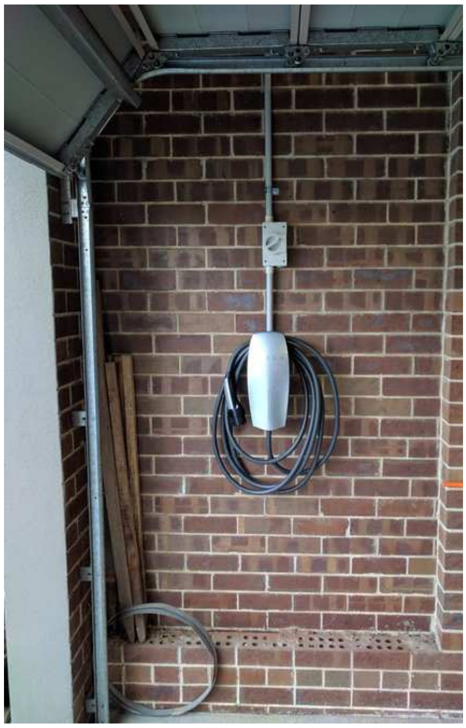
Now to our Electric Car

Currently, the energy for our road transport networks comes from fossil fuels—mainly oil. The idea behind transitioning to an electric transport future revolves around replacing this oil with electricity, which in turn it is hoped might be created from non fossil fuel sources. However when we dig beyond the “green gobbledegook” and actually get our calculator out, we soon discover that this idea simply can never work in any capacity - either now or in the future. A universally adopted “electric car” will quickly result in astronomical energy costs and spell the death of our already stressed national electricity grid.

First, let’s consider our “electric car.” We haven’t included heavy vehicles such as trucks and buses in our study just yet. Here, we’re just going to consider the idea of replacing petrol and diesel driven private cars and light commercial vehicles such as utes and SUV’s, with electric.

For today’s calculations we’re going to use the Tesla Model 3. We can consider this a “typical” modern electric car for the purpose of calculating charging power and time against distance travelled for a “light vehicle” under two tonnes. Obviously charging power required by larger electric vehicles serving the needs of SUV and Light Truck users will be considerably more—however we can take the Tesla Model 3 as being generally representative for our calculations.

Lets start by setting the parameters of our study:



- In typical usage, the lions share of car owners both business and private, will want to use their car during the day and then charge it at home during the night, ready for use the next day.
- Although the typical average daily Australian commute distance is only **16km,** the typical travel distance for a private car in Australia is around 20,000km per year. Assuming the car travels nowhere on at least 1/4 of days in that year, this means the *“average” electric car will be expected to travel around **73km per day***.
- Given typical Australian usage patterns, it can be expected that on some days, owners will want to be able to have the option of using their electric car over far longer distances. These will likely extend upwards to the limits of vehicle range. In the case of the Tesla Model 3 this averages at around **402km.**
- There are several levels of “home” charging available for the Tesla Model 3. Quoted from their web site, the table below outlines the charging options available. *The column outlines the number of kilometres a vehicle could be expected to run after **one hour of charging at the nominated rate**.*

Charge Power (kW)	Phase + Amps	Model 3		
16.5	3phase 24A	75		
11	3phase 16A	75		
7.4	Single phase 32A	50		
3.7	Single phase 16A	25		
2.3	Single phase 10A	15		

- For accuracy, we also have to consider the number of vehicles in our study. Typically most suburban households in Australia have **at least two cars**, sometimes three. If each of these is expected to be used during the day, **all of them will need to be charged at night** at the same premises.
- Considering the above, a reasonable expectation will be that a typical “all electric car” household will probably invest in one large “wall” charger of 7.4 or 11kW capacity, plus also use one or several smaller chargers of 3.7kW and 2.3kW concurrently for the second, third or visiting vehicles. The vehicle with the most depleted battery and which runs the greatest distance, will use the wall charger, while the others will likely be “topped up” using smaller charging options.

In search of a “typical example,” we’re going to take an average 3 bedroom suburban house with a single phase 80A supply. Typical “all electric” home with solar hot water (4.8kW electric booster), one air conditioner.. and two electric cars. Both are used for daily commutes of around 98km and 24km respectively. Weekend trips of up to 150km can be for either car. An elder son of the family also owns an electric car. He lives away during the week and often returns home on weekends and needs to charge his car at that time.

It’s a rainy, winter’s Friday night. All three cars are hooked up to charge. The air con is on, warming the house. The solar water heater booster is also on after everyone has had a shower. It switches in when the off peak rate starts at 10pm. The typical demand is;

- 32A to charge the main car
- 16A to charge the second car
- 10A to charge the third car
- 12A for the air conditioner
- 20A for the water heater
- 5A for other small loads around the house.

A total of **95 amps.**

In the dark... at around 10:15pm... the call is put to the electricity company to come and replace the main fuse.

Again.

Meanwhile next door, a self employed plumbing business owner is a bit more tech savvy. He's had an electrician install three phase at the board so they've got a lot more juice to play with. It's a bigger, double storey four bedroom house with ducted air and a separate granny flat for one of the older kids out the back. To enable a faster charge for his new electric 4WD ute and the family car, he's installed two 16kW wall chargers in the garage plus a few 15A outlets outside for visitors and his older kid's car.

So at 10pm, around the same time as the electricity company rock up next door, his mains are looking like this:

Phase	**A**	**B**	**C**
Charger 1	24A	24A	24A
Charger 2	24A	24A	24A
Charger 3	16A		
Charger 4		16A	
Air Con	8A	8A	8A
Water Heater 1			20A
Water Heater 2 (Flat)	20A		
Other loads	10A	5A	10A
Totals	**102A**	**77A**	**86A**

No sooner has the electricity company's ute pulled out of next door's driveway after replacing their fuse and telling the house occupants to disconnect two of their electric cars.. the owner of the three phase house is out in the street hollering at them to pull into his driveway instead…

<u>The Bigger Picture</u>

We could go on for ages with these examples. However let's now go back to considering those **sixty houses** we were talking about at the start of this paper. Let's start by assuming that all of the single phase houses have now been progressively upgraded to three phase, as owners buy electric cars and have electricians install chargers in their garages. Instead of around *5kW,* night demand for each house now averages at something around *12kW.*

As a result, the so called "off peak" demand on our poor 400kW transformer shoots up to something like **720kW.** The power company has to fork out around $600,000 to split the load to a new transformer at the other end of the street, now leaving around 30 houses on each transformer.

To handle the tripling of the "night" load, the power company now has to do the same thing with their 11kV network. They begin to insert additional zone substations in between the existing ones at around $50 million a pop. Magnified across the whole country, this augmentation cost quickly spirals into **billions of dollars**. The power companies have to pay for all this somehow.. *and guess what?*

That's right! They do it by ***<u>increasing electricity charges</u>!***

Under these conditions, the "demand curves" and pricing structures of last century around which our existing networks were built, get turned on their head. **The cheapest time to buy electricity is now in the middle of a sunny day,** when roof top solar is churning out thousands of surplus megawatts.

The <u>most expensive time</u> to buy power is <u>in the evening</u> when there is *no solar capacity at all*. Everybody returns home to cook a meal, switch on the air conditioner and connect their car to the charging outlet. Demand "peaks" in the late evening and then stays high throughout the night until the car charge loads are removed from the network in the morning.

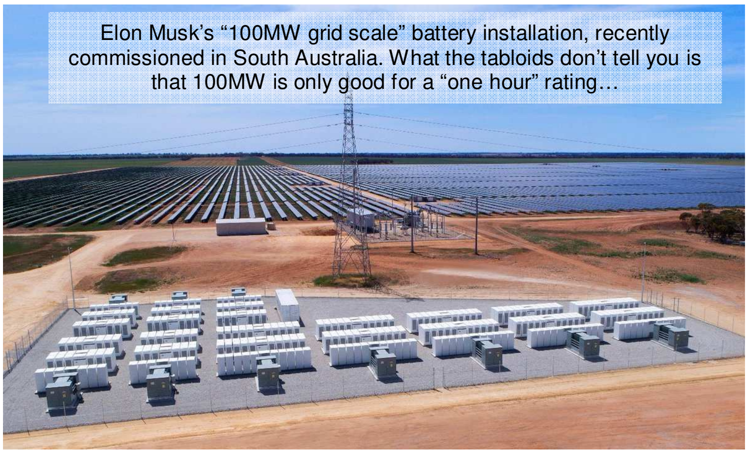
As a result, the concept of having a cheap rate for night time "off peak" power quickly becomes nonsense. The power companies begin to charge much higher rates at night, only dropping to a low "off peak" rate for just a few hours in the middle of the day when all that rooftop solar is producing excess electricity. Power costs, especially for those using electricity for water heating, suddenly shoot through the roof!

The *cost advantages* of owning an electric car under these conditions become *quickly eroded*. It becomes cheaper to just buy petrol than to charge an electric car at home. To make matters worse, due to less petrol being sold, the government is now losing millions in fuel excise tax - as cars shift from petrol to electric. In order to maintain road maintenance budgets, ***new taxes are introduced on electricity*** **and electric car charging**, to "level the economic playing field." This pushes up power costs even further.

Where is all this electricity going to come from?

Mount Piper is NSW's **NEWEST** coal fired plant—built 37 years ago in 1983. More than 6GW of coal plants are reaching the end of their economic life in NSW alone.

In case nobody has noticed, there's already a few problems with the stability of our national electricity grid in Australia. Aside from the problems introduced by ever increasing intermittent power sources *(for the full story read my other paper on "Power networks for Dummies")* and the fact that over 6,500MW of coal fired generating plant in NSW alone is approaching "end of life" with the newest plant built as long ago as 1983, we also have the compounding issue of ever *increasing demand* in a country which maintains an immigration rate of over 200,000 per annum and where brand new suburbs and cities are sprouting from fields like grass after a storm.



Elon Musk's "100MW grid scale" battery installation, recently commissioned in South Australia. What the tabloids don't tell you is that 100MW is only good for a "one hour" rating…

A recent paper released in *December 2019* by AEMO (the Australian Energy Market Operator) titled the *"draft integrated system plan"* (or ISP), endeavours to create a "road map" for our network into the future for the next twenty years or so. Alarmingly, *this document contains glaring errors, omissions and assumptions* that will almost certainly put energy reliability at risk—and that's before we even mention the issue of electric cars!

The ISP report starts by drawing five *different possible scenarios* ranging from "do nothing" through to "fast change" toward a carbon neutral network. While some of the theory appears to be sound (apart from the obvious frequency stability issues), it's clear that kindergarten kids could add up better. The first ridiculous mistake is that in all their scenarios, **AEMO has assumed no growth whatsoever in demand**!! In fact, all options in the ISP show a clear REDUCTION in dispatchable energy. *This is crazy!*

That's right! If you don't believe me, here's a graph taken straight from the ISP report showing the proposed overall ***dispatchable capacity*** in the East Australian network in coming decades. Thats the squiggly line, right in the middle. All five scenarios are shown:

Figure 11 Power system development across five scenarios

The ISP report goes on to outline how **around 80 billion dollars of investment** will need to be spent in coming years in order to supposedly allow for the gradual transition from thermal generating plants to renewable sources such as solar and wind. **These costs are *for the NETWORK alone*!** *They don't even cover the cost of actually creating the electricity itself!*

The ISP proposes construction of **enormous interconnectors** between Queensland, NSW and Victoria in order to allow power from one end of the country to be fed to the other as demand shifts according to the weather in each state. It is proposed these connectors will also run through vast stretches of outback and regional Australia, so huge solar and wind farms can be connected to the network. Coupled with storage such as Snowy 2.0's "pumped hydro", "large scale battery" and "behind the meter battery", it suggests that if we completely ignore the need to synchronise the AC network and instead pretend to manage it like a bunch of water filled reservoirs where we can move energy around at will—then we **just might be able to meet current (2020) demand** whilst at the same time supposedly weathering the storm of reduced generation through retirement of ageing coal fired plants, which currently provide more than 70% of the network's energy on a 24 hour, seven day basis.

The engineering practicality of using a distributed high voltage AC network for this kind of thing is the stuff of playschool. It has never been tried before anywhere else in the world and is well beyond the scope of our discussion here. The important thing to remember is that all the planning in the ISP report has quite ridiculously assumes that **electricity demand in the future will remain more or less the same as it is today.** It assumes that the main contributor to demand in our current network at any given time is rightfully attributed to ***air conditioning use*** which in turn, can be predicted to follow weather patterns.

This great scheme assumes that if it's hot in Victoria, then it will be cooler in NSW and Queensland. Power can then be taken from Peter and given to Paul. A few days later when the weather has changed and it's sunny in Queensland, hot in NSW but cool and cloudy in Victoria, Paul can then give some of it back. The idea is that over four states (including Tasmania, linked with DC interconnectors) **demand will remain static at around 40 Gigawatts for the next 30 years**. This, despite the fact that population is expected to balloon on the east coast and entire cities are planned for construction where none exist today such as with Western Sydney's "Aerotropolis." Not withstanding this, it doesn't even take into account the ever increasing **densification** of **existing suburbs**, where typically three to six town houses (each with a new 17kW feed) continue to be built on lots which previously connected only one.

The DER (Distributed Energy Resources) LIE

In the ***AEMO report's own admission***, it claims that "**overall demand will be held constant by Distributed Energy Resources**" (DER). *So just what is "DER"* and why do they think this will *prevent demand from increasing?*

"DER" is a catch all term for what is supposedly created when we marry **solar or wind** sources with **batteries**. The idea is that the batteries can be charged during periods of high wind or sun and then discharged when energy is most needed. However there's two major problems with considering DER on a consumer scale:

1.) Space

No matter how much we invest, there is only so much space on suburban roofs for solar panels. Even less available on units and apartment blocks. Therefore, there is an *absolute limit to the amount of energy that can be collected* this way per premises. **Many buildings today have already reached this limit**. If demand in a building exceeds supply, the difference must be made up by the electricity network. The additional load represented by electric vehicle charging in the home dictates that it would be impossible to meet even 20% of this demand using "DER". *Even the most effective solar / battery installation would be rendered flat within two hours of delivering energy at a rate of 11 kilowatts per hour to charge a car battery!*

2.) Losses

What everyone seems to keep forgetting is that **every time we store electrical energy, we need to convert it.** Batteries, chargers and inverters all create waste heat which represents precious lost energy. If (for example) someone intends to use their solar array to charge batteries, which will then later be used to charge another set of batteries in their car at night, this represents *"double losses".*

Energy is lost three times:
- When the panels first charge the DC batteries
- When the electricity from the batteries is inverted back to 230vAC for the house
- When this 230vAC is now converted back to DC again to charge the car batteries

So in reality, the **equivalent solar panel size would need to be about <u>40% larger</u> than if the panels charged the car directly**. Unfortunately that can't happen, because **the car isn't home during the day** and the sun doesn't shine at night!

In the AEMO report, all of the "scenarios" rely very heavily on these **"distributed energy reserves"** in order to supposedly maintain dispatchable capacity whilst apparently allowing for the retirement of life expired coal plants without replacement.

<u>Fast Chargers and Public Charging Networks</u>

Until now, we've mentioned little about other options available for charging our Tesla Model 3. However there are some. This growing network of "public chargers" is designed to take the place of local service stations.

These "public chargers" are very high capacity units—typically over 80kW each. They connect directly to the DC batteries in the car instead of relying on the smaller AC charger located within the car itself. Typical charge times can be around 30 minutes to charge a Tesla Model 3 from 20% to 80%.

Do the electrical maths.. and we quickly discover the *nasty sting* in the tail of these units! For Tesla's fleet, there are two models available:

- A **50kW unit**, which can charge from 20% to 80% in about **45 minutes.**
- A whopping **150kW unit,** which can charge from 20% to 80% in about **20 minutes.**

A single **50kW charger** demands about **80 Amps per phase** from the network. This is more than the entire capacity available in a typical domestic *three phase* connection! The killer **150kW unit** will need a circuit breaker no smaller than **200 Amps per phase** at the meter board.. ***<u>And this is just to charge ONE Car!!!</u>***

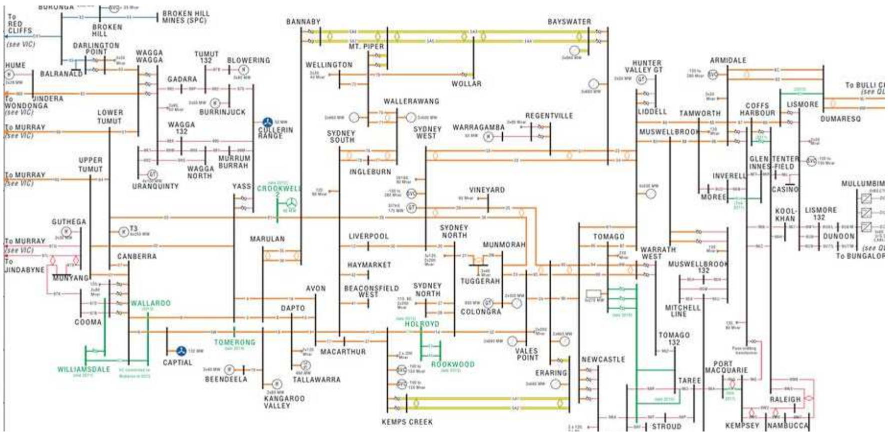
A “charging centre” typically consisting of just eight of the 150kW units, would require an 11kV substation on site capable of delivering **around one megawatt!** To put this in to perspective, a substation of this size would typically be employed to supply energy to an entire *medium sized suburban shopping centre*. These are *truly astronomical figures*—and certainly not the kind of installation you can expect to just “drop in” to any existing suburban location without very substantial and expensive network augmentation.

Remember… the installation has to be dimensioned with very low diversity. The reality of ***all chargers*** *operating at* ***full power*** *on a* ***regular basis*** is very high.

For a brief moment, let’s form a picture in our mind of charging stations like this “popping up” everywhere, all around suburban Australia. Literally hundreds of them—potentially thousands—in a city the size of Sydney or Melbourne. Then... Lets read on... below….

The effect of electric cars on the national grid

We’ve taken a look at what happens at home. We’ve considered that in order to provide for home charged electric cars on a wide scale, local power networks will need to be augmented by a factor of at least three and that the delicate balance of electricity bill shock is very likely to suffer as a consequence—even to the extent that “fueling” electric cars may end up becoming more expensive than with the existing petrol and diesel fleet.



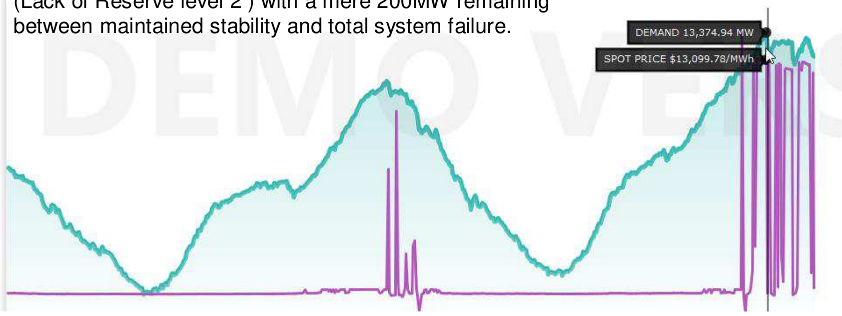
Even if we were to somehow deal with all the enormous problems above and electric cars somehow remained viable, we still need to consider their effect on the *national electricity market*. Unlike many other electrical loads, **electric cars represent load on our network with *very low diversity***. By definition of the way we use our cars, **charging them will generate enormous peak loads on our electricity network at night, just the same as our cars now cause peak hour chaos on road networks every weekday morning.**

For the first time since the introduction of “off peak” electric water heating, we’re planning to make a seismic change to the ***way we use electricity***. Only this time, it’ll be by factors *tenfold* of those that were made previously.

Everyone wants to connect their cars to their charger at the same time at night. This load will remain for hours instead of minutes. The network will need to be robust enough to provide for this additional load **on top of** all the existing loads already on our network. Unlike with the off peak water heaters, there’s no real scope for us *to take existing loads and shift them to another time.*

Each and every single electric car “added” to the network **represents addition of a significant load that previously wasn’t there at all**. This means to calculate the effect on say, the NSW electricity network is quite easy:

NSW's average electricity consumption at 10pm at night currently hovers around the 7,300 megawatts mark. **The absolute maximum demand hovers around 13,500 megawatts** on the hottest work days of the year. (source—AEMO 5 minute dispatch graphs)



NSW Electricity demand on Friday 30/1/2020. The jagged blue line to the right shows how large industrial loads (such as Tomago Aluminium Smelter) were forced off line in order to maintain network stability. On this day both VIC and NSW were declared LOR2 (Lack of Reserve level 2) with a mere 200MW remaining between maintained stability and total system failure.

Back in 2015 the ABS reported there were ***5,247,199 registered vehicles in NSW***, of which around 60% (or 3,673,039) were *cars or light commercials*. If we investigate a reasonable "electric car" penetration rate of about one third of this total, that should give us a snapshot of what things might be like when we have around 1,212,102 electric vehicles in NSW.

To keep things realistic, we'll also assume that only ***one third*** **of these will be "on charge" each night.** The other third will either be on the road being driven, at their destination, or otherwise not needing charge. That delivers just under <u>400,000 cars which will likely be connected and charging at 10pm each week night.</u>

Inevitably, some will probably be connected using slower "standard power outlet" style chargers. Others will be connected using fast, three phase chargers. The difference should therefore be more or less equal to the mean in the middle. For our calculations we can assume then, that **each car is connected to a *standard single phase wall charger*** and that this is <u>operating at around **7.4kW.**</u>

Using these simple and very conservative calculations, we can see that this will add an <u>**extra 2,960 megawatts of load**</u> to the NSW network around 10pm. *To put this in perspective, the entire maximum output of Mount Piper Power Station, NSW's newest (1983) coal fired plant, is a mere 1,400MW.* So it's reasonable to see that in simple terms at least, **NSW would need to add at least two more "Mount Pipers" just to keep up with this demand**.

The mathematics gets positively horrifying when we start to apply this seismic shift in load profile to the proposed "renewable" generation presented in AEMO's "ISP report". To provide for this kind of daily capacity without resorting to fossil fuel base load, would require *hundreds of billions of dollars* of additional investment in network infrastructure. It will need further *hundreds of billions of dollars* in the actual generating assets themselves like solar and wind—if it is *even possible to use these sources to provide such energy continuously* for the eight hours or so that the charging loads will be drawing power from the network.

There simply isn't enough suitable land in NSW on which such massive solar or wind plants could even be established, without significantly impacting on our national parks and existing agriculture. There is nowhere near enough water in any river system capable of supporting the kind of "pumped hydro" capacity that would be needed to deliver this kind of dispatchable capacity... ALL NIGHT.

If we even suggest using "grid scale battery" technology, we would need an installation more than **thirty times** the size of South Australia's so called "Elon Musk" battery plant. Even then there would be no guarantee that enough energy could even be stored in it to last the eight or so hours it would take to charge 400,000 vehicles overnight and also cover for winter or cloudy days at the solar farms.

Of course the other thing we've neglected to include in our calculations, is the issue of <u>*network losses.*</u> As any electrical engineer will tell you—<u>*all electricity networks have losses.*</u> For every kilowatt we put in to the NSW network we're lucky to get about 900 watts out of the other end. Over multiple interstate links this can be as low as 700w. So in reality, our electric cars will add a demand of around ***3,250 megawatts***. It would be like the network is running on a hot summer work day.. but every night of the week.

This means that NSW would need to find an **extra 3,250 megawatts** of reliable, base load generation in order to allow approximately one third of the existing car fleet to be converted to electric. These calculations were simple, conservative and based on measured load as provided by electric car manufacturers.

However the future in this regard gets even more scary once we start considering some of those other aspects we conveniently "left out" of our "simple" models;

Heavier Vehicles

Despite the fact that we have concentrated on cars, most admit that the true potential for electrically powered vehicles is in the **heavy vehicle fleet**—buses and trucks. Tesla have been busy in this market also.

Already plans are advanced for a production model electric semi trailer combination, capable of taking the place of most conventional diesel powered fleet. Tesla alone already has over 2000 pre paid orders from notable transport operators in the US alone.

As of yet, the charging current draw for the Tesla Semi is not quoted on their web site. However it can be expected that a charger capacity of around 1MW per truck could be expected. A typical transport yard might see six or eight of these on charge at a time—over 8MW—and likely needing at least a 33kV supply into the yard!

Even conversion of *only 20%* of our current truck fleet to electric would inevitably add *thousands more megawatts of load to the electrical grid*—at all hours of both day and night.

Then there's **electric buses—**already a reality in many countries. The NSW Government recently announced a program to acquire over **8000 new electric buses to replace it's ageing diesel fleet**.


This fleet of electric buses has been in operation at Sydney Airport for over four years now for the "Blu Emu" car park service.

These buses use batteries of around 330kWh capacity and consume around 80kW per hour under normal driving conditions. Buses typically operate for long hours during the day, which means the pressure will be on to provide very high capacity for charging them at night.

We don't need to be a rocket scientist to work out that **each bus** will need access to a charger of **at least 100kW,** running *continuously all night*, in order to charge it ready for the next day's service. With a typical depot containing *well over 100 buses*…. that's at least **10MW per depot.**

NSW's fleet of "8000 new buses" will effectively require the power output of *yet another Mount Piper generator to charge each night*.

So.. Lets do some simple arithmetic to take a snap shot of loads in say, in *only eight years time*:

One third existing car fleet converted to electric :	~ 3,250 MW
One third existing truck fleet converted to electric :	~ 880 MW
8000 new electric buses in NSW (50% on charge) :	~ 660 MW
	~ 4,790MW

If we wanted to draw a realistic goal towards a zero carbon emission solution (i.e. a total retirement of oil powered vehicles) **this figure would quickly triple to well over *15 gigawatts***—more than double our networks current capacity!

As you can see… electric cars are a wonderful dream. Doubly so, if we could meet the demand without resorting to the use of fossil fuels. However when we hand the idea from the scientists to the engineers to make it all work, the **mathematics just does not add up**.

Not without bringing the **"nuclear"** elephant back into the room.

Sorry.