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Standing the test of time!

Are lithium batteries on safe foundations?

Inside

Battery charging or discharging?

You can have it both ways.

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Battery charging or discharging? You *can* have it both ways.

Technical editor, Dr Mike McDonagh talks to Thomas Wick, the inventor of the Teiszmann bi-directional, buffered battery solution (3BS) charging system— which he believes could be the answer to grid-linked, superfast charging points for EVs.

Energy storage is a vital component in the battle to reduce carbon emissions. It is vital for two principal reasons:

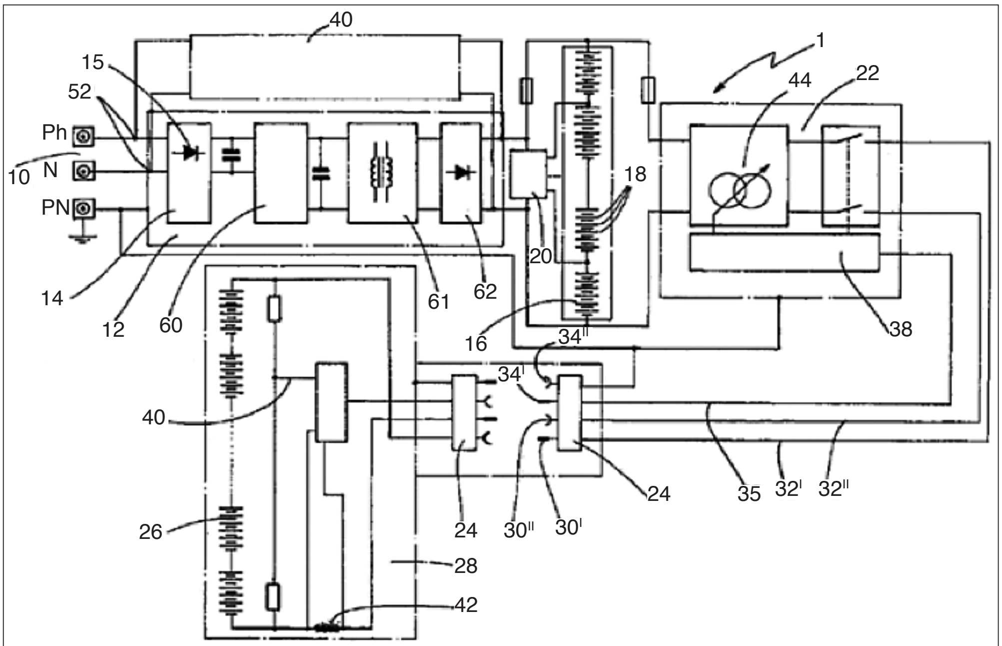
- It allows more efficient use of renewable power generation for when it is required.
- It can help to establish fast charging and standard charging stations for EVs.

In both cases there is a need to put generated electrical energy into an electrochemical store and to then use that energy when required. In the first case, it is needed at peak demand periods; in the second, it can provide very high-power outputs for a few minutes to fast charge EVs.

What is required is a system that permits energy to flow easily in two directions allowing connections to share energy when they need it. According to the Teiszmann company they have developed:

"A patented bi-directional charging system that answers this need and allows energy from storage devices such as batteries to flow in two directions. With this system, even the battery in an electric car can be used to pass energy to a home, community or grid if required."

Fig 1 shows a diagram of the operating principle of the charger taken from Teiszmann's European patent. ***What then are the advantages of this***



Drawing Number	Equipment	Drawing Number	Equipment
1	Charging System	30^{I},30^{II}	Charging contactor
10	Ac Power	32^{I},32^{II}	Cable
12	Power charging stage	35	CAN-BUS
14	AC/DC Converter	36	Control device
15	Diode Bridge	38	Controller
16	Buffer battery	40	Linear voltage increase
18	One cell	42	Shunt
20	Battery management system	44	DC/DC converter
22	Fast charge stage	52	Feed in point
24	Charge limit	60	Power factor correction
26	Vehicle battery	61	DC/DC converter
28	Electric vehicle	62	High frequency diode bridge

Fig 1: Schematic from the European patent of the Teiszmann 3BS bi-directional charger

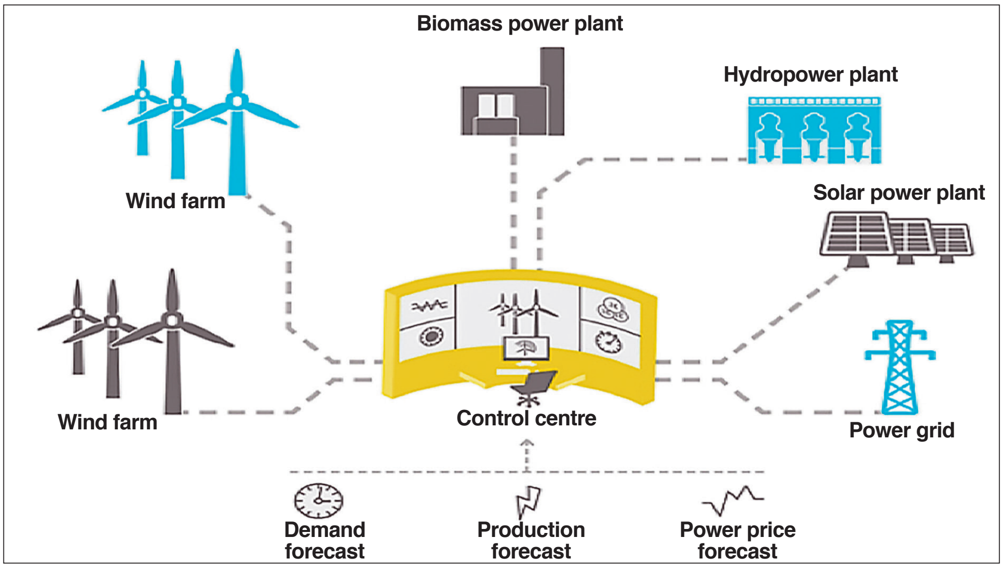


Fig 2: Network array showing the Internet-of-Things connected grid

technology? The main focus seems to be the use of a large buffer battery in a variety of different applications. This can range from BESS to fast EV charging. The bi-directional charger can both supply and deliver power from a single unit, cutting out the need to have an array of inverters and converters with subsequent efficiency losses.

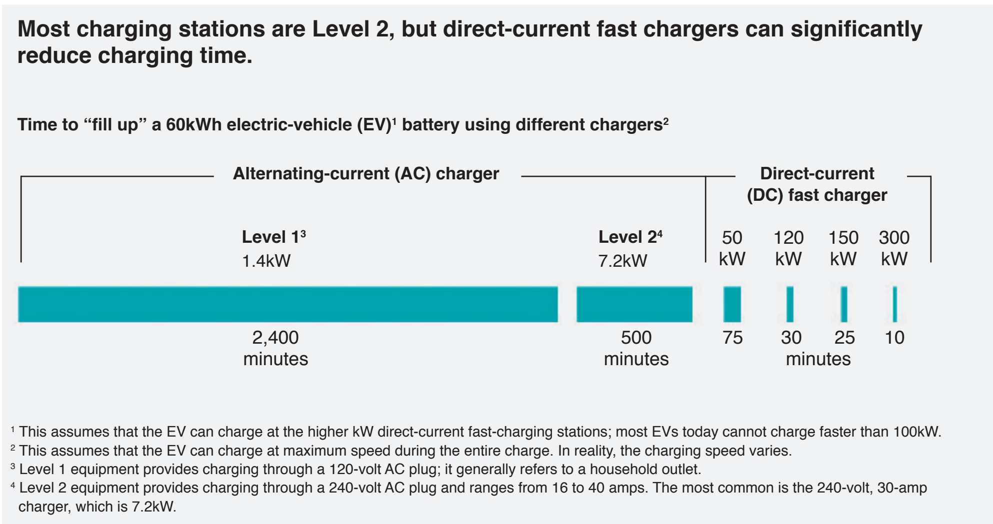
According to Teiszmann they have technology that allows having a smart system of renewable energy generation and energy storage, controlled via a dedicated IoT (Internet-of-Things) cloud network and big-data analytics platform in order to have a perfect virtual power plant ***(Fig 2)***. This, (according to me) is a misnomer as the power generation units within this entity are real not virtual. The 'virtual' label is derived from the use of a cloud-based data centre to control distributed energy resource (DER) generators such as wind farms and solar arrays, in combination with battery energy storage, to provide power when and where needed within a network of connected generators. This has obvious advantages for reliability, frequency control and peak shaving etc., as well as providing opportunities for commercial supply companies. However, the possibility of cracking the EV dilemma of an insufficient number of charging stations and the slow speed of charging is really the potential jewel in the crown of this technology.

The general public is currently somewhat reluctant to purchase electric vehicles. One of the concerns is the lack of infrastructure providing suitable charging points as well as the slow rate of charging. It's also fair to add that recharging at current rates is not as cheap as we might expect. In the US, for example, there are around 16,000 charging stations and only 2,000 of those are fast-charging.

McKinsey estimates that around 11 million BEVs will be on American roads by 2030. In this case, not only the number of charging stations but also the turn-around time at the nozzle and the number of nozzles per station has to drastically improve. It is reasonable to assume that this situation will be largely mirrored in most European countries.

Looking at the problems mentioned, the turn-around time is related to the nozzle output (ignoring the charge acceptance parameters built

Fig 3: level of charging available from different chargers at a charging station (McKinsey report)



into BEV automobiles). Most charging stations are level 2, or for the more technically-minded, their output is between 7 and 19kW. This clearly means any BEV with a battery capacity above 20kWh (most are between 50 and 80kWh) could take up to 12 hours to charge, at best, 2.5 hours with a small battery and the highest rated charger output. ***Fig 3*** shows the charging time for an EV with different charging levels.

Building more stations with higher nozzle outputs would seem to be the answer, but this too is not so straightforward. The power supply to deal with say 10 nozzles of around 20kW each is a large industrial project requiring a peak load capability of 200kW. And this still does not give us fast charging. To reach the 20 minutes that most surveys have concluded is the maximum reasonable waiting time would require an installation capable of providing a peak output of 2.4MW— ouch! And we're not finished there. The cost of installing this station and the running costs have to be taken into account.

Apart from the huge infrastructure and grid connection costs, there is also the cost of electricity. A large part of this is the demand charge, a monthly levy, based on the peak output of the installation. This can be higher than the electricity costs, around US$35 per kW output per month the last time that I looked. For a 2.4MW output that would be $24,000 per month— double ouch! That and the amortisation costs would have to be recovered on top of the $0.12 (approximately) per kWh of electricity actually going into the vehicle.

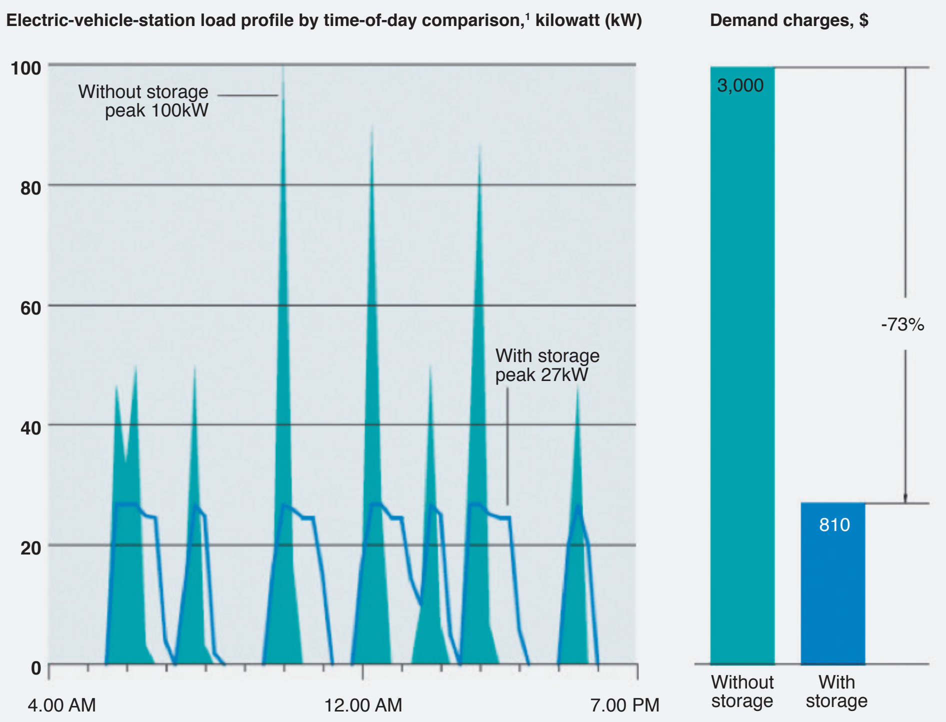
One solution to this could be to use renewables, which would avoid the demand charge tariff. Unfortunately, both wind and solar technologies are land hungry, expensive and less than 100% reliable. A sudden rush of EVs at a station at night when there is no wind could be very embarrassing. ***So what is the solution?*** Teiszmann's answer is the bi-directional charger.

The idea is to use a large energy storage device, the size dependant on the output of the nozzles, the number of nozzles and the frequency and time of use. This battery could be primed from the mains at a steady rate or charged during off-peak hours to reduce electricity costs. It would then be able to supply all or a proportion of the power to reduce the total kW peak demand and keep costs down. ***Fig 4*** is an example using a 2x 50kW charger output station, and shows the effect of reduction in peak demand which is attainable using energy storage.

In this situation it can also be paired with renewable generators to keep operating

Fig 4: Effect of battery storage on peak demand charges for an EV charging station (McKinsey report)

On-site battery storage at an electric-vehicle station can help smooth out load profile charging from the grid when no vehicles are present.



[1] This assumes (i) the station has four direct-current fast-charging 50kW chargers; (ii) 11 charging sessions occur during the time period profiled (4AM to 6PM); (iii) there is at least one instance where two cars charge simultaneously; (iv) the demand charge rate is $30 per kW; and (v) the battery-storage system is 150kW and can discharge at up to 75kW.

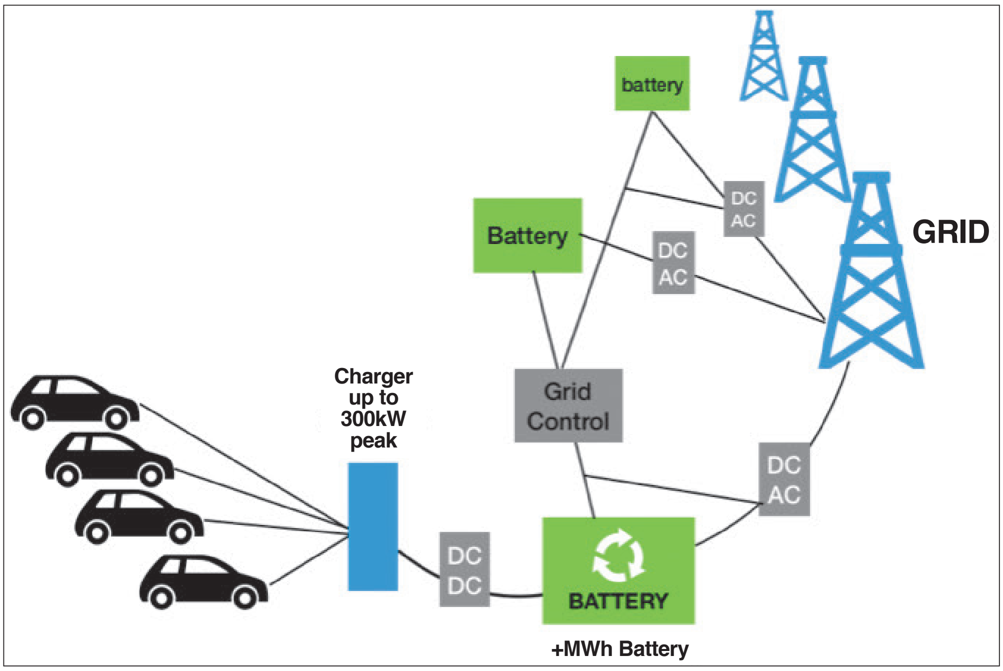


Fig 5: Charging station linked to IOM on a multiple power supply grid network

costs to a minimum. ***Fig 5,*** supplied by Teiszmann, shows a scenario of multiple BESS grid-linked inputs to a charging station made possible by a bi-directional charger.

It was against this background of providing technology, which can assist in the take-up of EVs and BESS installations, that I decided to find out more about it from the inventor, Thomas Wick, and his work to date.

What is the nature of your business and how was it formed?

ASMO stands for Anti Smog Mobile and was founded in 1987 with the goal to build electric vehicles and participate in solar car races. In 1992 ASMO became a company dedicated to develop electric scooters and smaller electric vehicles.

How was the idea of the Teiszmann 3BS created?

We developed chargers in order to charge the EVs that we were producing. In 2006 ASMO got a contract to develop a BMS (battery management system) and started work on fast charging stations on the Swiss motorway in 2008. The idea for this technology came when we stopped one day at a charging station and saw that they were limited by the power available.

There was an incident in the early 2000s when one of the big powerlines in Italy came down and the lights went out across half of the country. We decided then to look in general at how to use battery back-up power and realised it was easier to have a bi-directional charger that could give and take energy from a large battery source. It would be universally applicable to many applications. To finance the patent of this technology we joined with the Swiss-based company, Teiszmann AG.

How would you describe the 3BS technology?

The Teiszmann 3BS is a patented bi-directional buffered battery solution for super-fast charging electric cars with integration of grid backup. As the world transitions from carbon-based fuels into electricity, the need to store renewable energy is becoming critical. The world is rapidly transitioning to stored energy for homes, communities and electric vehicles. The grand vision is that of a connected community that shares and uses energy more efficiently.

Until now stored energy could only be used in one direction. What was required was a system that allowed energy to flow easily in two directions allowing connections to share energy when they needed it.

The Teiszmann company developed the solution: a patented bi-directional charging system.

Up to that point, it had not been possible to fast charge several cars at the same time with the power coming from a standard grid connection.

This is a quick-charging station for electric vehicles with a controlled process of the charging algorithms. The success of electro mobility depends on the density and functionality of the charging infrastructure.

What experience and in-house knowledge does the company have in this field?

ASMO was for many years the leading supplier for electric go-karts, where fast charging (up to 3C) was a must. We had a high frequency 120A 48V fast charger, Ziban, from Italy, which we had to modify for 3C charging. Later on, the manufacturer changed the design to allow for this higher rate of charge. The batteries were 40 to 60Ah and we charged at 51.2V.

Thomas Wick

What is your relationship with Teiszmann and what is the status of the invention?

I am the inventor of the Teiszmann 3BS bi-directional charger. The CEO of Teiszman, Daniel Schneider, owns 50% of the patent and I have the other 50%. This arrangement was made in order for Teiszmann to fund the patenting and marketing as well as provide development resources. I have a shareholding in Teiszmann and I work as a technical consultant to Teiszmann to help in their vehicle development programme.

Considering that fast charging of EVs and energy storage already exists with all possible applications like peak shaving, frequency control, DR applications etc., what advantages does the 3BS charging system have?

Basically, we agree that there are the same or similar systems as ours already in the market. However, we patented the system at a stage when no one was really thinking about a functioning infrastructure. The reluctance of the industry is nothing to do with producing good electric cars, but the lack of infrastructure for charging the vehicles. The customer wants to be able to cover long distances reliably. In addition, we provide primary energy to the grids, which, depending on the expansion, will have enormous advantages for the grid operators. Wind and solar energy can be stored at any time and retrieved when needed. Our competitive advantage is therefore in the early patent application, which gives us some security in marketing and rollout sales compared to our competitors.

What is the energy efficiency of 3BS compared with conventional switching systems using an inverter and battery charger in energy storage applications?

We expect it to be around 90% from the tests we made with DC/DC charging at low power, but as we haven't tested it in the real world we can only base this on theoretical knowledge.

You are claiming improved power quality. Is this an improvement in the power factor, i.e. the reactance of the circuit?

Due to the fact that we are using a big buffer battery we are able to correct the phase displacement to around 1. Again this is theoretical as we have not tested the whole system under field conditions.

The fast charging of EVs is very topical, but what about the vehicle battery? There are limitations on current and voltage set by the vehicle and the battery BMS. It is costly to increase this.

When we started developing this system some car manufacturers claimed that their battery could be charged in 10-15 minutes, but the chargers were not able to do that.

We quickly realised that only the battery cells could be charged in that short time.

Anyhow, I think our job is to provide a maximum of available power. The BMS of the car has to tell the charger how much it can take.

The power transfer you mention i.e. 500kVA would charge a Tesla car battery in around 10 minutes. A large battery bank could provide this but could the vehicle accept it?

This is not our problem. So far the cars are dimensioned for the maximum motor power. I think in the future the limit will be set by the maximum charging power. Cars will need to have a communication system compatible with any charger as must the battery pack. The 3BS will have a communication system that will obtain the protocol and have a translator. All we require is a code system and the co-operation of the EV manufacturers.

You have mentioned rapid EV charging as a primary goal of the 3BS technology. What about the connection system and the safety aspects with a current draw of possibly several 1,000s of amps at battery voltages of over 300V?

Yes the safety aspects are a concern, but there are companies who manufacture high-power DC/DC converters. We do not think that there will be major problems in reaching this goal.

What sort of size of battery and current draw from the grid do you envisage for these charging stations?

The battery size for a typical motorway service station would be between 1 and 2MWh. This is based on the fact that there are about 1,000 cars a day that refuel at an average service station. If there are 20% electric cars this makes it 200 charges of an average of 50kWh, so your power demand is 1MWh per day. This also gives you the average current draw from the grid which is 1MWh /24h is 42kw constant charging power. This is a very low load for the grid.

Do you have any plans drawn up for a charging station that include the size, ground space, engineering aspects and cost?

The space needed is the size of two 40-foot containers. Ideally this would be powered from a renewable energy resource installation such as a wind turbine or a solar array.

This type of project lends itself to use of renewable energy sources. What proportion of energy contribution would be envisaged? Consideration of local conditions will of course apply, but perhaps a general estimate could be useful.

There is a huge potential to use renewable energy. The contribution depends on the dimension of the buffer battery and the available energy sources as well as on the intention of the operating company.

Do you have resources to build a prototype and are you in touch with any potential investors?

We have human resources but we do not have the financial resources to build a 1:1 prototype. The estimated cost of a workable prototype with fast charging station is about €1.5 million.

What discussions have you had with EV manufacturers to synchronise your technology with their vehicles?

We haven't had any discussions with car manufacturers yet as our system would work with any kind of battery voltage. Software is the key for the communication with the individual cars and this still has to be developed.

Do you have a roadmap for the implementation of this technology and how dependant is it on partnership funding?

We do not. It is 100% depending on finding the right partner and the funding.

Would you welcome investment partners at this stage, and what could they expect?

Yes, of course, and we would offer an appropriate participation in our patent.

Finally, where may this technology lead you?

We are convinced that the market for our technology is huge, even more so as we strongly believe that there will not be a real alternative to battery-buffered fast-charging

stations in the near future. Our technology will avoid a network expansion and it will help to stabilise the grid. Power sharing is also not necessary.

There we have it. According to Wick, there is a cost effective and credible solution to the shortage of EV charging stations. With the Teiszman 3BS charging method, he believes the cost of installing and operating a multiple-point, fast-charging station for electric vehicles would be seriously reduced. With the actual energy cost being only a fraction of the total, it makes sense to reduce the additional burden of capital overhead and peak demand charges to a minimum.

Use of the bi-directional charger will remove much of the requirement for AC/DC conversion equipment and enable the more effective use of energy storage batteries that can seriously reduce peak demand charges. With the prospect of reduced overheads and lower peak demand costs, it is far more likely that potential entrepreneurs will see setting up EV stations as a commercially viable business enterprise.

Modular, stackable, energy storage units and the ability to tap further into renewable resources, enable the expansion from a small to a larger station with little problem. It also seems that the benefits go far beyond those of business interests. A viable charging network for electric vehicles operating from an integrated network including renewables has to be good for local and global air quality. Of course, in the long term it could be a major step in realising the ultimate goal of a global carbon-neutral economy. It's what we all want and it is companies like Teiszman who are leading the charge towards this currently elusive aim.