Local DC Power

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Abstract

The energy sector is about to undergo a major transformation. In this poster, we discuss the best possible energy solution for a smart and green community. This poster focusses on the decentralized power generation, storage and distribution through photovoltaics and lithium batteries. It encompasses the need for local direct current (DC) power through the factors driving this change. The importance of local DC power in the surface transport sector is also established. Finally, we conclude with data bolstering our argument towards the paradigm shift in the power network.

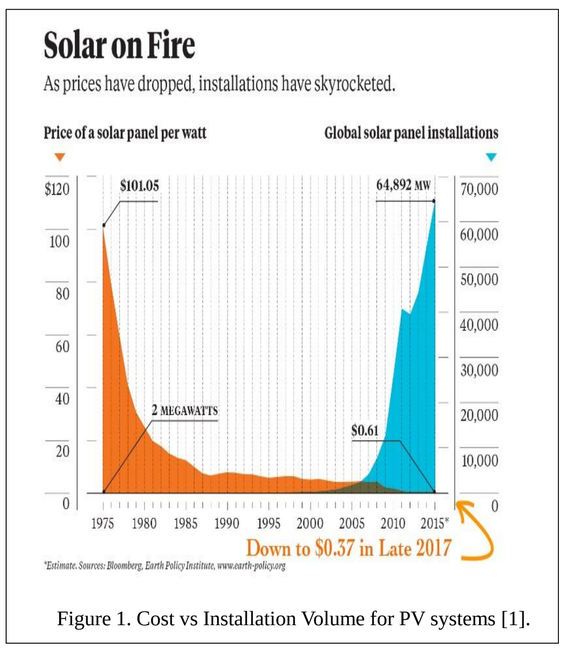
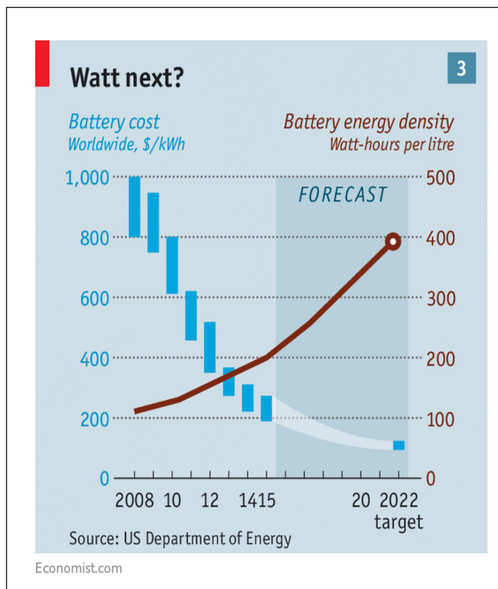


Figure 1. Cost vs Installation Volume for PV systems [1].



Lithium-ion battery vs Energy Density [2].

Need for Local DC Power

The electricity industry is at the cusp of a dramatic transformation. The drivers for this paradigm shift are:

1. Real-time grid monitoring [3]
2. Emergence of microgrid and nanogrid in place of centralized integrated electric grid [3]
3. Improved energy efficiency [3]
4. Cyber security in the grid [3]
5. Weather tolerant electricity infrastructure [3]
6. Intelligent loads [3]

Important example of need for DC power in lieu of the issue of climate change

We know that climate change is a grave issue faced by humanity today. Carbon emissions are one of the most important causes of climate change as we can see Fig. 3.

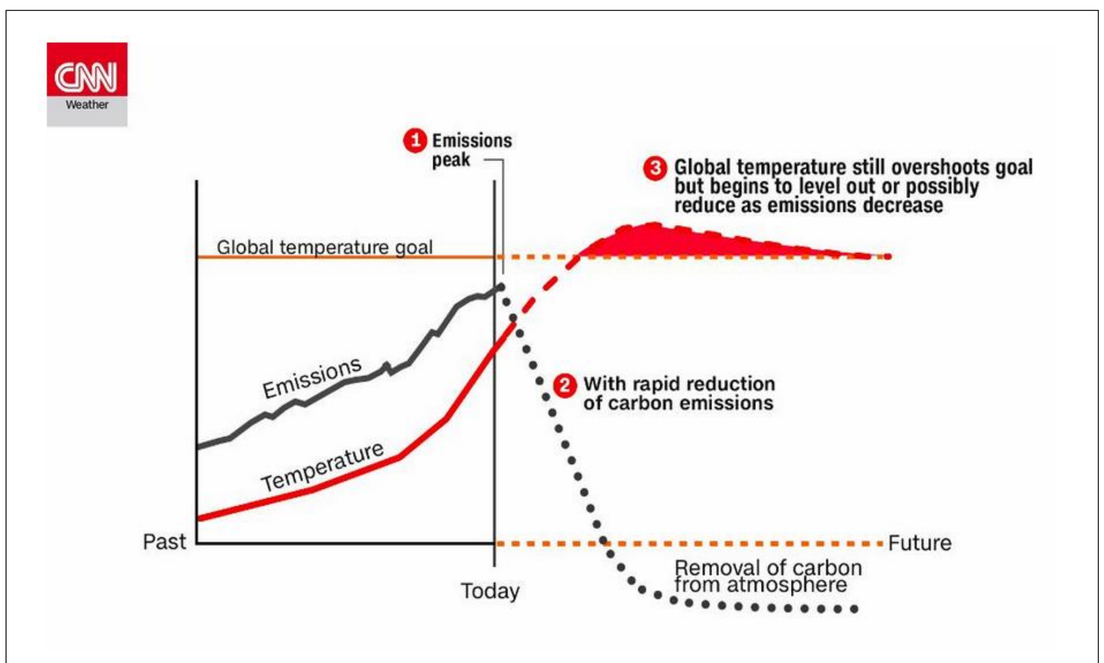


Figure 3. Ground zero of climate change by CNN [4].

From [5], we have data that the overall solar global capacity for last year has risen to 407 GW. Considering an average usage of 5 hours a day, we can calculate total usage per day as (407*5) 2035 GWh.

Table 1. CO2 Emissions per kWh with coal and natural gas energy production [6]

Fuel Type	Kg of CO2 emitted per kWh
Coal (Bituminous)	0.94
Natural Gas	0.55

We can conclude that, on an average, coal and natural gas produce 0.745 kg of CO_2 per kWh. Therefore, based on the data, we can offset 1516e6 kg of CO_2 emissions.

It takes approximately 1.6W of DC power to generate 1W of AC power depending on the inverter sizing factor. Thus, we lose 254 GW of power and consequently 948e6 kg of CO_2 emission savings. Hence, a DC power network is not only efficient, but also plays an important role in curbing the effects of climate change.

Proof of Concept Data

We setup two experimental setups to bolster our argument for DC power vs AC power as follows:

A. DC vs AC battery charging

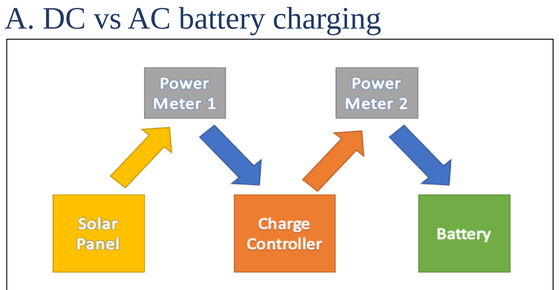


Figure 4 (a). DC Charging Experimental Setup

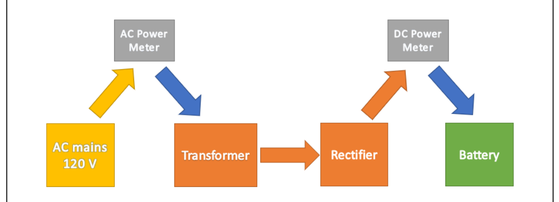


Figure 4(b). AC Charging Experimental Setup

Results:

Parameters	Power Calculations		
	Average input power (W)	*Average output power (W)*	*Power Loss (%)*
DC Power (W) (Before Absorption State)	43.2	39.375	8.85
DC Power (W) (After Absorption State)	20.31	17.44	2.87
AC Power (W)	59.05	31.45	46.74

The DC charging incurs lesser losses due to fewer conversion components involved in its network. This experiment demonstrates the increased energy efficiency of DC charging as compared to the current AC technique.

B. On-board PV for battery operated golf cart

Results:

Parameters	Without Solar	With Solar		
	Sunny	*Sunny*	*Cloudy*	*Rainy*
Distance in miles	27.05	53.68	49.81	49.59
Time in minutes	241	390	362	360
Improvement in Distance over Without Solar	--	98.45%	84.14	83.33
Improvement in Time over Without Solar	--	61.83%	50.21%	49.38 %

In order to determine how the on-board solar panel would improve the electric golf cart performance, four types of trials were conducted in different weather conditions. It can be seen in the results that the on-road time and distance of the golf cart has considerably improved with the inclusion of on-board PV panel.

Conclusion

Based on the research conducted, we conclude that local DC power is shaping to be the energy network for the future. Our data indicates how local DC power is beneficial to the surface transport sector. It can cause an overhaul by introducing more efficiency and cost savings in the surface transport and ultimately the energy sector. With proper policy, PV and battery-based local DC power grids will be the main mode of the energy generation, storage and consumption.

References

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Acknowledgement

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