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In the next decade, the number of electric vehicles (EVs) on our roads will likely rise substantially, and we believe the bulk of the charging of these vehicles will take place at home.But readily accessible charging away from one"s home (or one"s workplace) will also be key to support EV growth. Such "on-the-go" charge-ups will also need to be as easy and convenient as refueling an internal combustion engine (ICE) vehicle today.

So how will the EV infrastructure support the developing fleet? Today"s automobile culture is supported today by an estimated 135,000 outlets with some 1.4 million pumps,according to the National Petroleum News. This network balances the competing demands of low cost and efficiency, locational convenience and capacity utilization. The result is that most motorists in most situations can easily find a competitively priced gas station and not wait in line for an open pump. We expect similar dynamics will shape the emerging network of EV charging stations.

Note 1: Typical EV fuel economy runs around 200 KWH per tonne-mile, so a typical 2.5 tonne vehicle requires about 50 KWH for a 100-mile run. EV manufacturers typically optimize vehicles to achieve the best possible fuel economy within other constraints (number of seats, performance, etc.)

Not surprisingly, the capital and operating costs of higher-capacity chargers (excluding the electrical power delivered) is higher than those of lower-capacity chargers. Level 1 chargers--like a residential 110-volt outlet--are nearly free to operate. Level 3 and 4 chargers, however, are more expensive and complex.

So how should we think about charging costs, and what are the implications of these costs? In particular, will consumers be willing to pay a premium for faster, high-level chargers? To examine this, let"s look at the costs of building and operating charging networks.

There are relatively modest returns-to-scale at the location level. That is, a higher capacity station (ie. one with more chargers) is not inherentlycheaper per KWH delivered than a lower capacity station. Today, the average number of chargers per location is about eight. These networks will likely evolve to more numerous--and hence more widespread--smaller-capacity locations with about four chargers each.

Once an EV charging station is built, all costs are essentially fixed, so utilization is key to achieving efficiency. Still, even a quite low utilization is likely to result in lines at busy times. In practice, the stand-alone, fast-charger industry uses a 20% utilization as a rule of thumb. But if a charging station is utilized at more than this 20% threshold, the operator will likely look to expand capacity or, more likely, add another site nearby.

Although fast chargers are significantly more costly to build, their greater capacity means that their overall

cost-to-serve (per KWH delivered)can compete with lower-capacity chargers even at lower utilizations.

In the emerging EV charging market, time-starved consumers will likely value their time highly enough to pay a premium for speed. They"ll look for convenient locations with the fastest charging times, and they"ll be disinclined to use reservations apps. Providers targeting these consumers will build extra capacity to maximize availability and offer the fastest chargers. They"ll also demand a significant premium over Level 3 stations seeking to capture value over and above the increased costs they incur.

The price segment consumer will likely go to Level 3 stations with higher utilization and, perhaps, in less convenient locations. Price-sensitive consumers may be willing to wait in line, shop around and reserve a charger via mobile apps.Out-of-town consumers in this segment use chargers near aggregations of restaurants (or retail or amusementdestinations), where they could occupy themselves while their car is charging.

In recent years, loyalty programs have become a critical competitive lever in the gas and diesel market. The loyalty segmentin EV charging may not develop to thesame extent, since a household"s total expenditure on away-from-home charging will be quite modest, representing only10 to 20% of their total consumption.For a vehicle averaging 10,000 miles per year, away-from-home charging will likely amount to roughly $300 per year, compared to at least $1,500 spent at the gas pump today.3

Nevertheless, we may see the emergence of bundles and other offerings,in which service providers and retailers offer charging as an incentive to drive subscriptions, traffic or other transactions and interactions.

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