Dear Ahmed,

As we discussed, I am a data Scientist doing research into the adequacy of the pole-mounted local distribution transformers (found in predominantly suburban and rural areas) to support high-rate "*Level 2*" charging of battery electric vehicles, such as the increasingly popular Tesla models.

Based on the limited hourly-metering data obtained so far (see page attached), it appears likely that "at home" charging of a single Tesla will overload a 15 kVA distribution transformer, and that two Tesla's will overload a 25 kVA distribution transformer. This may be of especial interest to PSEG, as there are relatively high concentrations of Tesla ownership in Long Island, where PSEG has more than a million customers (and by year-end perhaps 370,000-plus type AMI/AMR meters, with 100% coverage in a few years).

In this context, I would like to work with PSEG to identify (via appropriate statistical algorithms) residences charging EV's at Level & Level 2 rates, and to help devise a work program that can become a nationwide best practice for allowing utilities to realize the full growth benefits from EV charging. Moreover, this work program might eventually use many of the workers currently engaged in installing the smart meters on Long Island.

Please find attached a brief introduction to my work. A more detailed report is available upon request.

I look forward to meeting with you and your esteemed colleagues in your offices. Please advise on some convenient dates.

Respectfully yours,

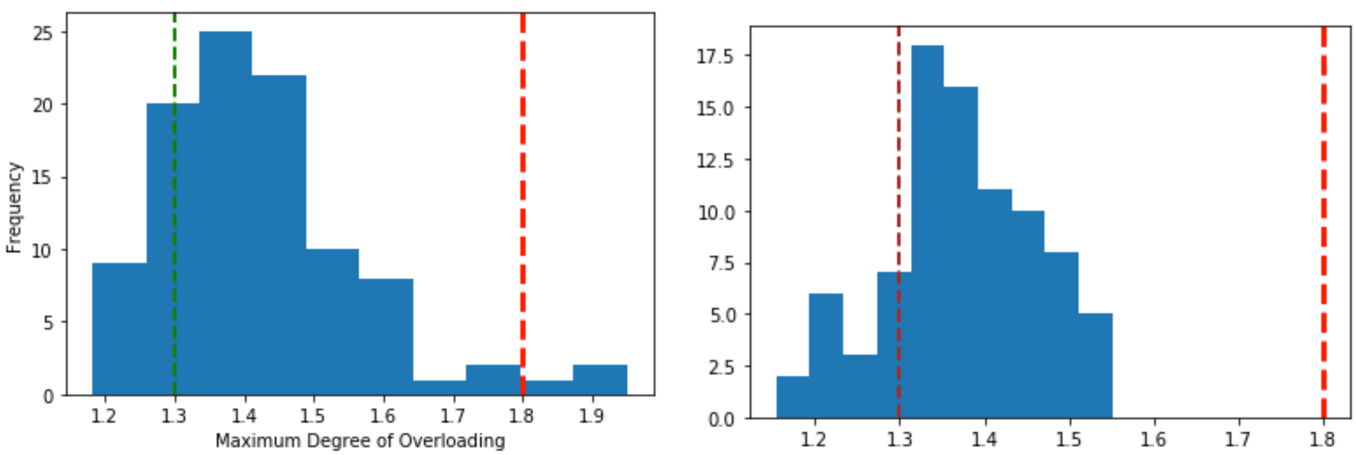
David Willson

<u>“*The One Tesla Problem*”</u>

Based on the limited hourly-metering data obtained so far, it appears likely that the “at home” charging of a single Tesla will overload a 15 kVA pole-mounted distribution transformer, and that two Tesla’s will overload a 25 kVA transformer. However, suitable statistical algorithms can detect a residence’s EV charging (whether a Tesla BEV or a PHEV) from hourly metering records, such as are available from even AMR-type meters. This is valuable intelligence, as even sophisticated utilities such as SCE reportedly know the locations of less than 40% of the EV’s in their service territory. This information can be used to (a) support direct mail campaigns to gather additional information, (b) conduct non-invasive tests to assess the remaining life of the relevant transformers, and (b) as appropriate, pre-emptively upgrade relevant transformers in terms of their size and insulation, and avoid paying a large (3-5x) premium for an emergency replacement.

The addition of a single Tesla charging at the most common rates of 30 miles’ range/hour and 45 miles’ range/hour can on its own overload a transformer, leading to exponential aging. These two charging rates would be pulling from the grid at a rate of 12 kwh and 18 kwh respectively. For example, for a 25 kVA transformer serving a median eight households, the old peak might have been 8 x 3kwh, or 24 kwh: however, with the addition of a single Tesla, the new peak will be now 36 kwh or 42 kwh, corresponding to overcapacity levels of 144%, and 168% respectively. At this latter level, unless a protective fuse is tripped (and they seem not to be always installed), a transformer explosion or fire becomes a danger.

Of course, the most extreme overloading will occur for the smaller transformer sizes, such as 10 kVA and 15 kVA: while these are less common (together may comprise c.44% of the number of 25 kVA transformers). The figure below (LHS) shows the frequency distribution for different degrees of overloading during the Summer months for 100 transformers, all assumed to be of 15 kVA capacity, each serving five households, just one of which owns a Tesla. On the RHS, the corresponding data for a 25 kVA transformer with two Tesla’s is shown.



This “*One Tesla*” illustrative analysis suggests that 74% of the 15 kVA transformers will experience a maximum overload of 130% or more, and 3% will experience a “potentially catastrophic” degree of overloading of 180% or more of capacity. The cost of an emergency transformer replacement is reportedly 3-5x that of replacing it in advance, so a modest investment in Analytics to anticipate and pre-empt overloading with appropriate upgrades seems to be well warranted, in terms of avoiding (a) the very-substantial emergency replacement cost premium, (b) reputation damage and a potential acceleration of the *Electric Utility Death Spiral*, and (b) reputation and legal costs associated with catastrophic transformer failures.

While the outlook for 25 kVA transformers is less dire with just a single Tesla, with two Tesla’s the likelihood of brown-out’s is high, although Catastrophic failures seem unlikely (above). Specifically, this “*One Tesla*” illustrative analysis suggests that 89% of the 25 kVA transformers will experience a maximum overload of 130% or more, but none will experience a “potentially catastrophic” degree of overloading of 180% or more of capacity. However, two Tesla’s for eight households and an average of 16 vehicles owned, corresponds to just a 12.5% EV penetration, which could be achieved in some counties of some states in the not so distant future.