SMACS MODEL
A Stochastic Multihorizon Approach for Charging Sites Management, Operations, Design and Expansion under Limited Capacity Conditions

Chiara Bordin, Asgeir Tomasgard
Department of Industrial Economics and Technology Management,
Norwegian University of Science and Technology, Trondheim - Norway
{Chiara.Bordin,Asgeir.Tomasgard}@ntnu.no

The increasing demand of electric vehicles creates challenges for the electric grid both on the transmission level and distribution level. Charging sites in particular will have to face strong challenges especially in those countries where a massive penetration of electric vehicles happened in the last years and even more is expected in the forthcoming future. Such an increased forecast demand will lead to a capacity lack within the existing charging sites, therefore new investments in design and expansion have to be planned.

We propose the so called SMACS MODEL that stands for Multihorizon Approach for Charging Sites Management, Operations, Design and Expansion under Limited capacity conditions. The model is built to analyse critical decisions in terms of transformer expansion, grid reinforcements, renewable installation and storage integration, over a time horizon of ten years, with a particular focus on the long term uncertainty in the price variations of the available resources. Long term investment decisions and short term operational decisions are addressed simultaneously in a holistic approach that includes also battery degradation issues and is able to tackle the optimal trade off between battery replacements, grid reinforcements and renewable installations throughout the chosen time horizon.

The key contribution is both methodological and analytical. On the methodological side, computational experiments has been carried out to compare optimal decisions taken with traditional deterministic approaches and decisions taken with multihorizon approaches with inclusion of long term strategic uncertainty. On the analytical side, computational experiments with real world dataset have been carried out to investigate which combinations of storage replacement costs and grid reinforcement costs make the system economical, with the objective to show under which conditions storage integration and renewable integration becomes convenient compared to grid reinforcement investments. Further tests have been done to investigate the effect of battery degradation on the long term decision making process and on the forecast optimised battery replacements throughout the chosen time horizon. The trade off between cheaper batteries with lower performance and more expensive batteries with better performance, combined with the long term forecast prices reduction, has been investigated to identify the optimal compromise between performance and costs over the forthcoming years. Finally, different results obtained by assigning different probabilities to the long term scenarios has been collected to show the effect of forecast variations on the decision making process.

The study shows that the ability to take decisions by considering the uncertainty in the future variations of investment costs of energy units is crucial, especially nowadays that technology improvement is drastically affecting the cost and performance of storage technologies and renewable plants.