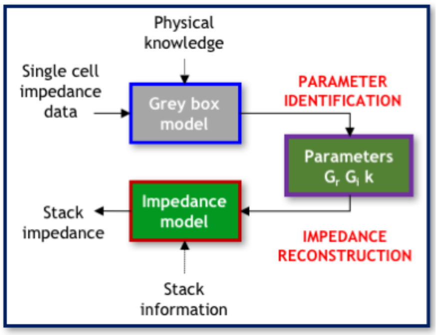
- Public Abstract -

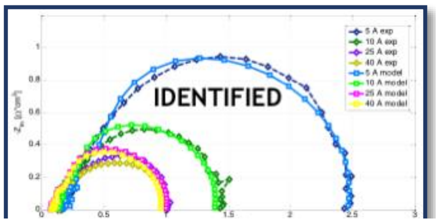
Deliverable D2.3 – Report on EIS scaling-up method

The current methodology for FCs control and diagnosis is based on EIS measurements and involves the analysis of the measurements through circuital modelling that might be time consuming and would require further work for its on-line applications. By exploiting the **Buckingham's π Theorem**, a key method in the similarity theory field, it is possible to reproduce PEMFC impedance spectra at different stack sizes (scaling-up) or operating conditions (e.g. current loads, operating temperatures, membrane humidification level, etc.), starting from a single cell/short stack EIS spectrum. From this unique spectrum, non-dimensional parameters are computed, and then the scaling-up is performed. The major advantage resides in its straightforward online applicability, thanks to very low computational burden, while preserving good level of accuracy. The approach, based on a fast modelling method, is suitable for design, control, diagnostics, state of health monitoring and prognostics.



The Buckingham's π Theorem states that if there is a physically meaningful equation involving a number *n* of physical variables, then the original equation can be rewritten in terms of a set of non-dimensional parameters π_0, π_2, ..., π_{p-1} built from the original variables. The novelty of this approach resides in its structure and development process: for the *identification phase*, the impedance layout is given by the measured data required for non-dimensional parameters evaluation, *G* and *k*, (without any ECM model), and the *scaling-up process* (i.e., impedance reconstruction phase) is fulfilled through physical reasoning (e.g. inference on fuel and/or water distribution).

In order to build the *PEMFC impedance at different current loads* only one test at a fixed current load is needed to fully characterize the FCS, provided that the grey-box model is valid. For the *scaling-up* approach two different analyses have been done: one for the *stack middle-cell* and another one for the *stack last-cell*. The results obtained for the full-stack impedance prediction have a precision comparable to equivalent circuit methods.



Data taken from D-CODE project final report.

A good accordance emerges between the experimental data and the model predictions. The possibility to use this methodology with scaling-up purposes is demonstrated.

Reference: Russo L., Sorrentino M., Polverino P., Pianese C., Application of Buckingham π theorem for scaling-up oriented fast modelling of Proton Exchange Membrane Fuel Cell impedance, Journal of Power Sources 353 (2017) 277-286.