PROPICE: Prognostics and Health Management of PEM Fuel Cell Systems

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Partners:

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FCLAB	Fuel Cell Lab, CNRS Research Federation, France
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Abstract

Fuel Cell Systems (FCS) appear nowadays to be a promising and alternative energy source to face economic and environmental challenges of modern society. However, even if this technology is close to being competitive, it is not yet ready to be considered for large scale industrial deployment: FCS still must be optimized, particularly by increasing their limited lifespan. This involves not only a better understanding but also requires emulating the behavior of the whole system. Additionally, a new area of science and technology emerges: prognostic of FCS is a field of scientific and industrial developments that should be increased. This is the aim of the project: the partners feel a clear motivation for such a research and propose to develop intelligent Prognostics and Health Management (PHM) methods in order to assess the health state of Proton Exchange Membrane Fuel Cell systems (PEMFC), and predict its remaining useful life.

To our knowledge, this is an original and still unexplored field: although the research in PHM is continuously increasing, one can note that efforts in the area do not deal with Fuel Cells applications. This may be (partially) explained by the lack of knowledge on the behavior of those systems. Indeed, it is difficult to develop prognostics tools that take into account the inherent uncertainty of not well understood failure mechanisms. In addition, prognostic presents deployment challenges: it is difficult to know how to set a prognostic tool, as well as is there is no systematic way to judge from it without waiting for the irreversible deterioration of the equipment. Following all this, scientific objectives of the project are defined as follows:

- develop approaches for reliable prognostics of PEMFC stacks;
- facilitate their implementation;

in order to move towards a generic approach compatible with industrial constraints.

Three related axis of developments are expected.

1. The first axis deals with handling the prognostic process. Here, the aim is not only to be able to estimate the remaining useful life of the fuel cell (provide prognostics estimates), but also to improve the capabilities of the developed prognostics tools by quantifying and controlling their inherent error of estimates. Several approaches will be considered: a model-based prognostic tool based on a Bond Graph approach with parametric uncertainty, and data-oriented prognostics tools by extending "signal" and "connexionist" approaches (like neural networks and neuro-fuzzy systems). The development of an hybrid approach will also be addressed.
2. The second axis scopes to enhance the applicability of prognostics tools. The purpose of this part of works is to look for solutions that enable systematizing the building of a prognostics system while reducing the influence of arbitrary human choices, as well as reducing its learning and/or parameterization times. Several options will be studied: the construction of adaptive and parsimonious systems, the definition of relevant "learning patterns", the identification of singular representatives learning samples, among others.
3. The third axis will focus on the industrial adoption process for fuel cells. The diffusion and transfer of results to industrials cannot be conceived without a precise knowledge of their expectations. It is thus necessary to understand the diffusion process of the Fuel Cell technology in the industrial world, and to identify the corresponding bottlenecks, other than those related to technological aspects. The project consortium has a competence in humanities and social sciences that will help to develop this axis.