



# INSIGHT

“Implementation in real SOFC Systems of monitoring and diagnostic tools using signal analysis to increase their lifeTime”

Grant Agreement n° 735918 –  
Research and Innovation Project

Deliverable D7.5 Teaching module for graduate courses

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**Project Coordinator:** Julie MOUGIN – CEA

**Contact:** Julie MOUGIN – CEA LITEN France - [julie.mougin@cea.fr](mailto:julie.mougin@cea.fr)

## Document Classification

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## Document Validation

Partner	Approval (Signature or e-mail reference)
P1 - CEA	
P2 - DTU	Anke Hagen - author
P3 - UNISA	
P4 - EPFL	
P5 - JSI	
P6 - VTT	
P7 - AVL	
P8 –SP	
P9 - HTc	
P10 – BIT	
P11 – AK	Eleonora Sartori



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## Document Abstract

The D7.5 presents the contents of the Task 7.5 “Education and Training Activities”. The consortium integrated this work in dissemination actions. The deliverable will show how project results are used during the project in the field of education. The project input is considered part of a teaching module or course, together with other input.

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## 1. Introduction

Solid Oxide Fuel Cell (SOFC) technology is moving towards demonstration and commercialization. In addition to comprehensive knowledge from laboratory test campaigns, more and more results from field and demonstration tests at system level are achieved, helping to identify the major critical issues under real operating conditions. Detailed information about electrochemical and micro structural properties from laboratory studies together with the input from field tests make it possible to establish methods for identifying the state-of-health of SOFC cells/stacks in the real system environment and to counteract potentially critical states. Such methods – as established in the Insight project – are an important tool for engineers of the future and are therefore implemented into teaching courses.

The slides in this deliverable will be used for a PhD course level, with the title: Introduction to SOFC and SOEC, and particularly in the lecture: “Degradation in SOFC / SOEC”. This course is part of a bigger Joint European Summer School comprising new energy conversion and storage technologies, which is held annually by a group of strong research and industry players in the relevant technologies. More detailed information is available at: <http://www.jess-summerschool.eu/>.

Project results are integrated in the course, together with other teaching material.

## 2. Teaching module

The topic was presented using the slides given below. The module is under further development and will be adjusted according to the needs in future courses.

The slide has a blue background with a stylized illustration of a city skyline and houses. In the top left, the text "Teaching module" is written in white. In the top right, the "insight" logo is displayed. At the bottom left, the names "Anke Hagen, Alexandra Ploner DTU" are listed. At the bottom right, project details are provided: "Grant Agreement n°735918", "Start date of the project: 01/01/2017", "Duration: 36 months", and "Coordinator: CEA".

Teaching module

insight

Anke Hagen, Alexandra Ploner DTU

Grant Agreement n°735918  
Start date of the project: 01/01/2017  
Duration: 36 months  
Coordinator: CEA



## State-of-health

### Objective:

- Monitor the state-of-health of cells/stacks while operating in the system in the field
- Identify potentially faulty states in order to be able to counteract and thus increase lifetime

### Requirements:

- Simple, cheap, robust method
- Preferably detection of a variety of realistic faults using one or few methods

### Approach:

- Test fault states in the lab with high degree of instrumentation
- Identify one or few unique parameters, which react specifically and early to be able to react on the fault

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## State-of-health

Realistic faults for operation of combined heat & power systems operating with natural gas fuel:



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## State-of-health

### Potential monitoring methods:



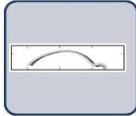
#### Temperature:

- Simple, cheap, fast
- Too unspecific?



#### Cell/stack voltage:

- Simple, cheap, fast
- Too unspecific?



#### Electrochemical impedance spectroscopy (and variants):

- Complex, less cheap, slower
- Very specific

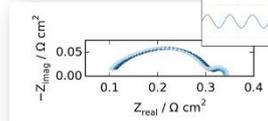
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## State-of-health

### Potential monitoring methods:

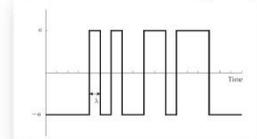
#### Electrochemical Impedance monitoring



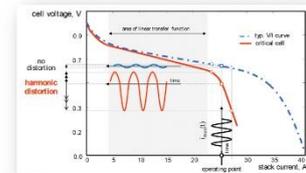
hardware requirements

Precision ↔ acquisition time

#### Pseudo random binary sequence (PRBS)



#### Total harmonic distortion (THD)



input frequency 'tracking'

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Figure 1 : Example of set of slides for teaching course

### 3. Conclusion

The slides shown here will be used for forthcoming PhD courses, also after end of the project. They are also usable for other teaching partners, both, from the project and also the teaching community as such. Because the specific type of course can be very diverse, these few basic slides are suggested, which can be enriched or detailed with more relevant information depending on audience and graduate level of the students.