# HyCoRA – Hydrogen Contaminant Risk Assessment
# Grant agreement no: 621223

# 1st Periodic Activity Report

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**Summary**

In this periodic activity report, the work progress of the first 6M of HyCoRA project is summarised.

In WP1 the use of resources and work progress has been somewhat uneven between partners.

In WP2 the progress has been according to work plan. The main topic of the first 6 months work has been to share the work between partners in the best possible way.

In WP3 the sampling campaign at hydrogen refuelling stations (HRS) has not been started as planned due to delay in the delivery of the gas sampler from Linde.

In WP4 the first version of qualitative risk model has been developed and is was presented in the first OEM workshop in Brussels on 30 September 2014.

In WP5 The first OEM workshop entitled "Hydrogen Fuel Quality Assurance for PEM Fuel Cells – Needs & Status, OEM workshop supporting risk assessment" was hold successfully in Brussels on 30 September 2014.

The management WP6 has been executed as planned.

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## Contents

1. Project objectives for the period ... 3
2. Work Progress and Achievements during the 1st Period ... 3
  2.1 Summary of progress ... 3
    2.1.1 WP1 Determination of susceptibility of hydrogen contaminants for automotive applications (VTT, CEA, JRC, PC) ... 4
    2.1.2 WP2 Development and validation of novel analytical methods for hydrogen quality assurance (VTT, CEA, PT, SINTEF) ... 8
    2.1.3 WP3 Assessment of hydrogen quality variation in hydrogen refuelling stations (VTT, PT, SINTEF) ... 12
    2.1.4 WP4 Risk assessment of hydrogen quality assurance failure (VTT, CEA, JRC, PT, SINTEF, PC) ... 13
    2.1.5 WP5 Dissemination, recommendations and communications (VTT, CEA, JRC, PT, SINTEF, PC) ... 14
  2.2 Deviations and impact ... 16
    2.2.1 VTT ... 16
    2.2.2 CEA ... 16
    2.2.3 JRC ... 16
    2.2.4 Protea ... 16
    2.2.5 SINTEF ... 16
    2.2.6 Powercell Sweden ... 16
    2.2.7 Summary of deviations and overall impact on the work ... 16
  2.3 The use of resources ... 17
    2.3.1 Deviations between actual and planned person-months per work package and per beneficiary in Annex 1 ... 17
    2.3.2 Corrective actions proposed ... 18
3. Project management during the period ... 18
  3.1 Consortium management tasks and achievements ... 18
  3.2 Problems which have occurred and envisaged solutions ... 18
  3.3 List of project meetings, dates and venues ... 19
  3.4 Project planning and status ... 19
  3.5 Impact of possible deviations from the planned milestones and deliverables ... 19
  3.6 Development of the Project website ... 19

# 1. Project objectives for the period

The objectives of the first 6 months of the project has been to start the research activities in all WPs. A central objective has been to organise 1st OEM workshop for receiving further guidance for the experimental work and development of the risk model.

# 2. Work Progress and Achievements during the 1st Period

The progress here is reported for those tasks, which have been active during the reporting period.

## 2.1 Summary of progress

In WP1 the use of resources and work progress has been somewhat uneven between partners.

VTT and CEA completed all the work for the deliverable 1.1 in Task 1. Therefore, the review on the impact of impurities on PEMFC and analytical methods for hydrogen quality assurance has been completed.

In Task 1.2 VTT has completed the work, while CEA and JRC are still developing and testing the measurement set-ups. The work by these partners is expected to be completed within the second 6 months period of HyCoRA project.

The work with reversible impurities has been started with CO as impurity. The first results by VTT have already shown the effect of high fuel utilisation and anode gas recirculation in the contamination rate.

In WP2 the progress has been according to work plan. The main topic of the first 6 months work has been to share the work between partners in the best possible way.

In WP3 the sampling campaign at hydrogen refuelling stations (HRS) has not been started as planned due to delay in the delivery of the gas sampler from Linde.

The first measurement campaign has been thoroughly planned. With a goal of sampling from HRS's with as diverse as possible feedstock, eight HRS's in Hamburg and Berlin were chosen.

The promised assistance of HRS operators in Norway (HYOP) and Germany (CEP) for sampling from refuelling station is very promising when it comes to the project resources required per HRS sample collected.

In WP4 the first version of qualitative risk model has been developed and is was presented in the first OEM workshop in Brussels on 30 September 2014.

In WP5 The first OEM workshop entitled “Hydrogen Fuel Quality Assurance for PEM Fuel Cells – Needs & Status, OEM workshop supporting risk assessment” was hold successfully in Brussels on 30 September 2014.

### 2.1.1 WP1 Determination of susceptibility of hydrogen contaminants for automotive applications (VTT, CEA, JRC, PC)

**Task 1.1 Knowledge review on impact of impurities on automotive fuel cells and analytical methods available for hydrogen quality monitoring. (M01-M04) (VTT, CEA)**

**VTT**

The deliverable 1.1 has been submitted and accepted. The main results of the deliverable were communicated in 1st OEM workshop. A review publication based on this deliverable is planned in co-operation with LANL and JARI.

A strategy for the PEMFC experimental research has been developed based on the Deliverable 1.1 and reported in that deliverable.

**CEA**

CEA has participated to the redaction of a public report on the impact on fuel impurities on the performance of PEMFC. CEA principally focussed on literature which reported experiments made on single cell or on lab-scale. The impurities of interest was CO and sulphur species.

The choice of CO was driven by its presence in H2 produced by SMR (Steam Methane Reforming) process. Nowaday, most of the production of H2 is covered by the SMR. The use of PSA (pressure swing adsorption) allow to remove most of the impurities present in the H2, however, due its low polarity, the CO is most difficults species (with inert) to remove from H2. Therefore, it is considered as a canary species.

The choice of sulphur species was motivated by its high impact on the performance of MEA. Even few ppb in the fuel can have dramatic effect on the MEA performances. Furthermore, there is now cheap method to allow the quantification of sulphur species in H2 at such low concentration. It is thus important to understand its impact on PEMFC.

The studies revealed that there is a gap in literature on:

- The effect of the recirculation of the fuel on the impact of pollutant. To summarize, is there an accumulative effect which would enhance the loss of performance; or is there a dilution effect which would decrease the impact of impurities?

- The effect of current cycle and SU/SD cycle (start up / Shut down) on the depollution mechanism.

**Task 1.2 Functionality of hardware materials for fuel cell measurements. (M01-M06) (VTT, CEA, JRC, PC)**

**VTT**

The functionality of the single cell measurement test station has been verified. The system uses anode gas recirculation and CO concentration in exit gas is measured with gas chromatograph. The results are reported in the Deliverable 1.2.

The system test bench (1-2 kW) has been developed for HyCoRA project and is operational. The description and characterisation results for the system test bench are reported in the Deliverable 1.2.

**CEA**

The task 1.2 can be divided in two pert. On the one hand the experiments at single cell level and on the other hand the experiments at stack level.

For the single cell level, CEA has validated the use of NEDC under pure H2 and has performed durability test on reference MEA (home made MEA) under pure H2 to have a base line for the project. A test station including a recirculation at the anode has been validated under automotive conditions (80°C, 50% RH, 1,5 bara). On that test station, the main has been focuss on the regulation of the recirculation loop. Some modifications have been mandatory in order to monitor it.

On stack level, CEA has mainly worked on the implementation of recirculation loop on the representative test station EPICEA.

- The hygrometers Vaisala and the measurement chamber have been received
- The Mass Flow Controler for the H2 line have been received
- A H2 recirculation compressor has been implemented, its monitoring is in progress in order to operate it under dynamic flow. Currently it has been validated under constant flow.
- The Air compressor has been changed in order two work with a 64 cells stack (10 kW) it allows a pressure control from 100 to 600 mbar and a flow from 11 to 21 Nm3/h)

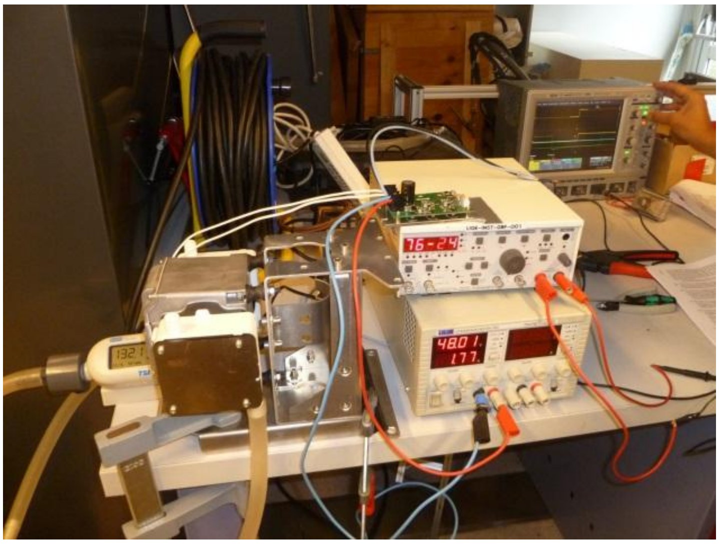


Figure 2.1: qualification of the H2 recirculation compressor

A Airsense gas analyzer (MS) has been rented. The quality measurmant of pure H2 and air has been scheduled for October.

**JRC**

Hardware functionality verification for the test bench with attached MS (mass spectrometer) analyser using $H_2$/CO gas was performed to validate the appropriateness of the measurements. Instrument calibration issues were encountered necessitating preventive equipment maintenance. In general, the CO reading by the instrument were very noisy at low ppm CO additions in the hydrogen gas.

The procurement of the fuel recirculation pump was initiated and the pump was delivered to build up with technical support by VTT the fuel recirculation loop as add-on feature to the test bench.

Figure 2.2: JRC test bench with atatched MS analyser

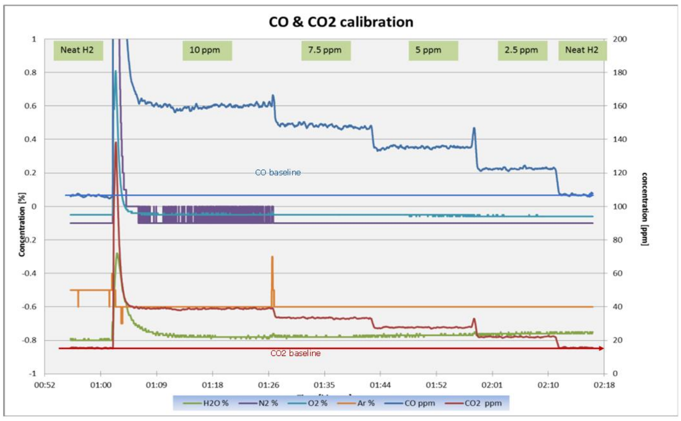



Figure 2.3: Example of MS analyser measurement for different CO concentration in neat CO2/$H_2$ gas

**PC**

A new soft goods configuration, tested and integrated in PCs S2 stack platform within the HyCora project. The first stack was built on request of the MEA manufacturer for evaluation of some production specific topics and tested only internally at PC during July. The second stack was build, end of line tested and supplied to VTT Finland in September.

Information about the testing environment at PC has been shared within the consortium. Scripts for end of line testing of HyCoRA fuel cell stacks have been developed.

PCs main contribution to the HyCoRA project is delivering stacks to project partners which are used for evaluating acceptable fuel contamination levels. It is critical that the anode loading of the stack is known within the consortium and therefore new soft goods with a different catalyst composition from PCs standard setup were sourced for this project. There has been substantial lead-time issues from several sub suppliers, however, hardware was available for first testing at PCs in August and in September the first HyCora stack was delivered to VTT Finland.

The first stack delivered to this project has a lower power output than the standard PC configuration due to a mismatch between the soft goods chosen for this project and the bipolar plate configuration, but the stack will serve the purpose of the project.

**Task 1.3 Study of reversible impurities. (M04-M34) (VTT, CEA, JRC)**

**VTT**

The work with reversible impurities has been started with CO as impurity. The first results by VTT have already shown the effect of high fuel utilisation and anode gas recirculation in the contamination rate.

The results also indicate that when cathode gas diffusion layer (GDL) is operating in semi-flooded conditions, the poisoning rate seems to increase due to change in current and water production distribution. The poisoning rate is highly dependent on the current density.

VTT has already started the work in Task 1.3 with some interesting results. In the following Figure is the poisoning times with different current densities, when current density is changed from 0.2 $Acm^{-2}$ to 1.0 $cm^{-2}$. As seen in the Figure, the poisoning time to reach voltage drop of 50 mV is increased by about 2.5 times, when current density is decreased by 0.2 $Acm^{-2}$.

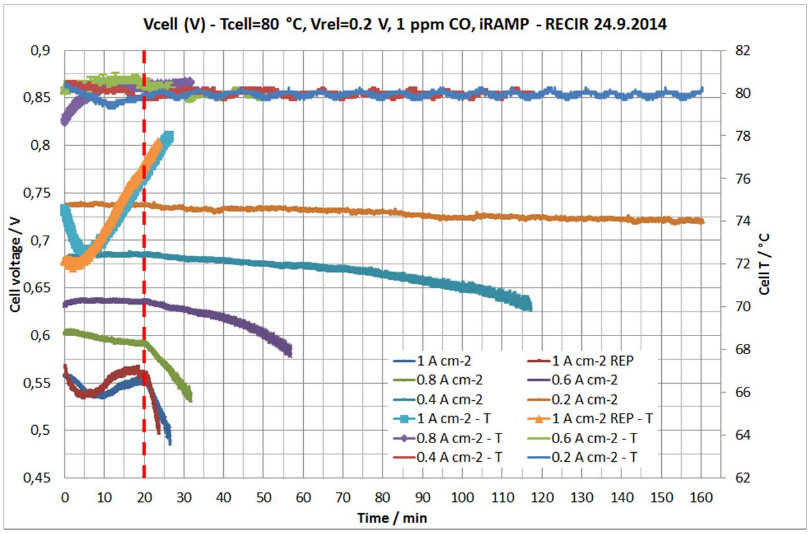



Figure 2.4 Comparison between different current densities. The CO injection was started at t=20 min.

There first results of Task 1.3 were reported as a part of Deliverable 1.2 as they could also be considered a part of reference measurements.

**CEA**

No work has been done in that task

**JRC**

Since fuel gases specification have not been made pending the outcome of the first OEM workshop, no gases could yet be procured so that testing of the impact of pollutant (CO in $H_2$) in open anode mode is postponed.

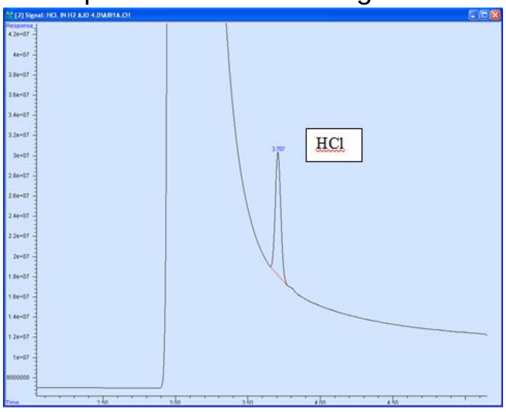
### 2.1.2 WP2 Development and validation of novel analytical methods for hydrogen quality assurance (VTT, CEA, PT, SINTEF)

**Task 2.1 Development and validation of novel and traceable accurate methods for hydrogen purity analysis. (M01-M34) (VTT, CEA, PT, SINTEF)**

**VTT**

VTT has carried out background work for the impurity analyses of hydrogen including study on the existing standards, applicability of various detectors, purchase of materials and setting up apparatuses.

After studying the possibilities of a pulsed discharge detector a new PDD was purchased from Vici Valco. It was assembled to an Agilent 6890-series gas chromatograph in the end of June. It was decided that in the beginning of the project VTT will concentrate on the HCl-analysis. Based on literature survey it was uncertain if PDD is sensitive to inorganic chlorine compounds. However, preliminary tests verified that this kind of detector can be used also for the analysis of HCl in addition to most of the other contaminants in hydrogen at low concentration level. We have also found out with PDD that chromatographic column HP-5MS can separate HCl from nitrogen and from hydrogen facilitating the analysis.



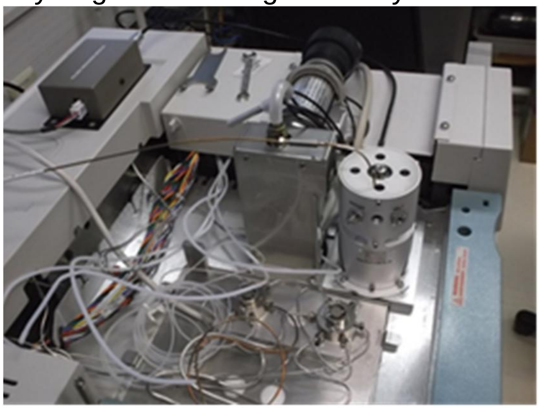


*Figure 2.5. a) HCl separated from hydrogen with PDD b) PDD installed on a GC.*

HCl gas standard at low concentration level has been ordered. After it has arrived we are able to verify the new method to analyse HCl at low concentration level from hydrogen.

Tests with the cold trap/ gas chromatograph - mass spectrometry (cold trap /GC-MS) analysis of technical quality $H_2$ (99.9 %) have been commenced. With the aim of concentrating the sample in injection, we have tested different amounts of $H_2$ to be injected to the cold trap using liquid nitrogen in the trap.

In order to analyse different kind of organic sulphur compounds from hydrogen, a literature review on the analysis was conducted.

**CEA**

In the frame of T2.1, CEA has evaluate the different analytical available on the market (literature survey) and has retained 2 technologies, which will be compared.

- Airsense (MS): which has been rented. It arrived at CEA in September 2014 and has been taken in hand. The measurement campaign is scheduled to be started in October.

- ProCEA (OFCEA): it allows to measure CO and H2S at low level. It has been rented for December 2014.

**Protea**

A review has been carried out of Protea's current product technologies – FTIR and MS – with the following developments begun for both technologies:

**FTIR**

A novel gas cell design has been started to enable long path length measurements in compact, low volume enabling a field-ready low concentration analyser. This will be followed with a high pressure operating design enabling sampling at pressure and giving increased IR absorption. This will make the most out of the proven, repeatable response of FTIR for trace impurity measurements.

The first stage of FTIR cell design has been to look at improving Protea's standard product gas cell from 4.2m to 20m to 30m. Optical design software has been implemented in order to plot transmission curves against cell length and volume for different systems.

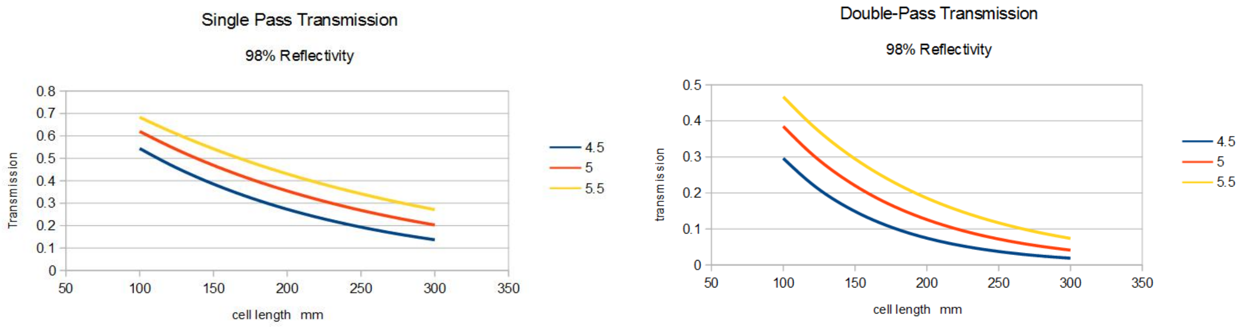



Figure 2.6. Transmission curves from new gas cell design variants.

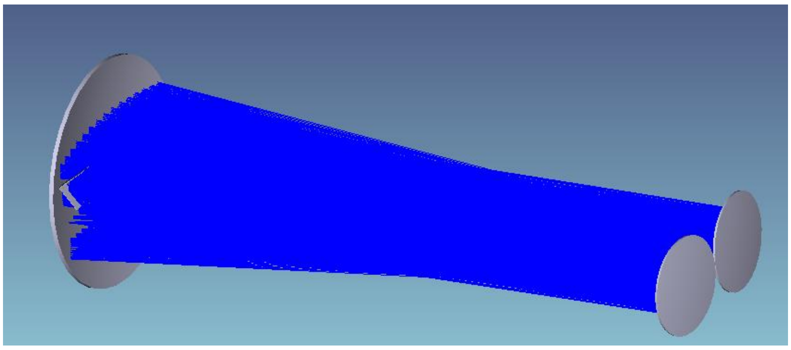


Figure 2.7. New gas cell optical ray design

Once the optical characteristics of the new gas cell have been finalised, the best mirror material and coating will be chosen in order to give the best R% but also offer long term robustness in the H2 environment.

**Mass Spectrometer**

We have updated the components of our laboratory MS to improve performance. This has included the use of a Pirani gauge to measure total pressure in the vacuum.

To account for the drift in MS response, we are investiagting the hardware variance against spectral response.

We have described, coded and delivered a data converter add-on to our spectral analysis software so now the MS data can be manipulated as required.

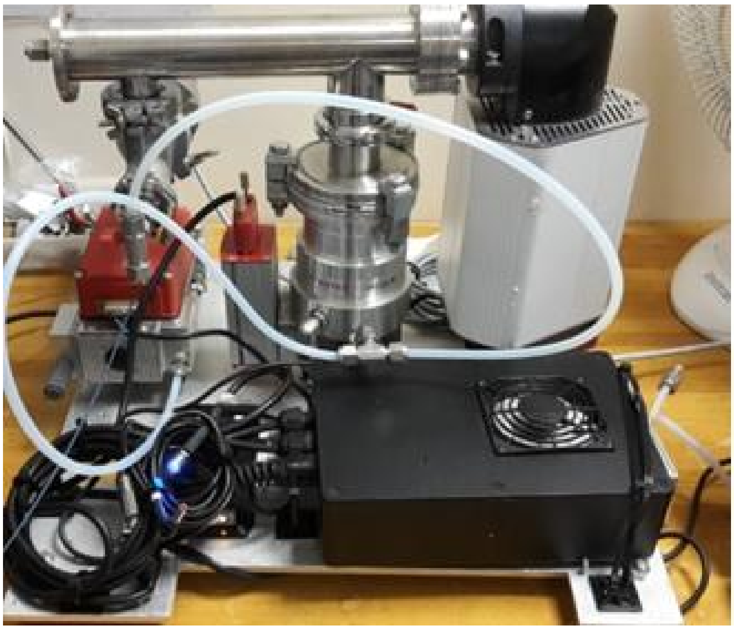


Figure 2.8. Mass spectrometer

**SINTEF**

A list of all proposed analytical methods for QC in compliance with prevailing standard have been compiled. The analytical capabilities of the consortium members have been added to this list. Based on this information, distribution of analytes between partners has been done. Special focus has been put on the total halogenates (VTT will apply GCC-PDD). Analysis of pre-concentated HRS QC samples is required in order to compile a list of relevant halogenate constituents: the prevailing standard has only used species listed for standard EPA emission protocols (TO 15).

SINTEF has been evaluating proposed analytical techniques for Ion Chromatography (IC). Model experiments where $SO_2$ in air has been absorbed in gas washers. IC techniques for total sulphur and total halogenates is currently being investigated. SINTEF analytical capabilities are mainly GC-MSD, GC-PDHID and Long Path FTIR spectroscopy. These resources are being readied for analysis when the fist measurement campaign. Especially, GC instruments has been retrofitted with coated gas tubings and multivalves for sample injection in order to avoid loss of sticky gases from sample container to analyzer.

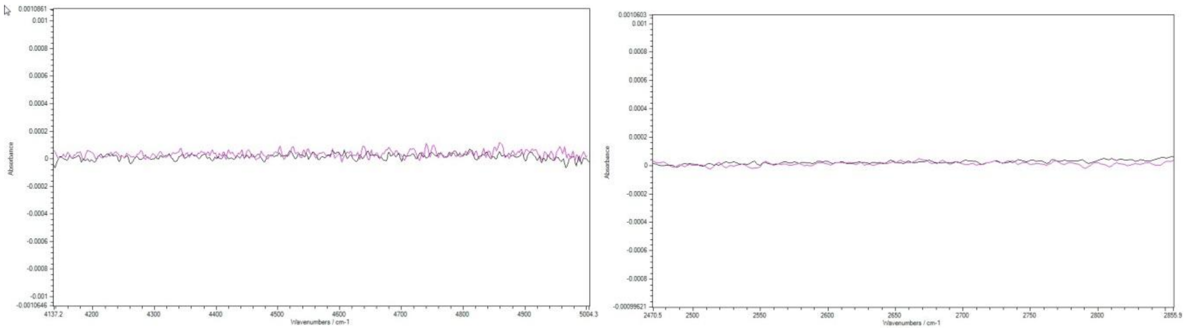
SINTEF has focused on the effort to establish a method for pre-concentration of impurities. Instead of constructing a device from scratch, collaboration with Argonne National Laboratory (ANL) has been established. A Pd-membrane concentration unit will be used by SINTEF in Oslo for HRS sample pre-concentration. This unit can potentially enrich samples by a factor of more than 500. Limiting is the Pd-membrane flux and tolerance for sulphur: the installed membrane tolerates sulphur well at the cost of hydrogen flux. SINTEF will try to optimize both the Pd membrane composition and fixture in order to improve flux. ANL scientists will visit SINTEF Oslo in order to discuss these topics in September 2014.

SINTEF will take part in the Round Robin laboratory test of gasesous samples containing CO and $H_2S$ along with CEA Liten. This will work as QA of the gas analyses being performed in HyCoRA.

Task 2.2: Testing and validation of new analysers for measuring multiple impurities (M01-M34) (PT, SINTEF)

**PT**

**FTIR**: MCT detector vs. DTGS (long scan).
For ease of use and reduced cost, removing the need for a cooled (LN2 or Sterling cooled) detector on the FTIR would make a more convenient product. We have looked at the responses of LN2 MCT cooled detector against longer scanning DTGS.



**FTIR Absorption plots in noise-level tested regions**

| Detector Type | #Scan @ 4cm$^{-1}$ | Sample Time / min | 2500 - 2800 cm$^{-1}$ | | 4200 - 4900 cm$^{-1}$ | |
|---|---|---|---|---|---|---|
| | | | p-p | rms | p-p | rms |
| MCT LN2 | 64 | 2.5 | 0.045 | 0.008 | 0.105 | 0.016 |
| DTGS | 64 | 2.5 | 0.108 | 0.023 | 0.198 | 0.046 |
| DTGS | 128 | 6.5 | 0.072 | 0.013 | 0.127 | 0.027 |
| DTGS | 256 | 12.25 | 0.039 | 0.007 | 0.096 | 0.015 |

Figure 2.9. Noise calculations for MCT LN2 cooled detector and longer scan measurements of DTGS

Taking a single long sample is preferred as the easier to use (and linear) DTGS detector can be used.

**MS**: Chemometric trials on MS data

We have begun to study the variance in MS response using PCA tools. This is indicataing that the MS vacuum needs to be left to stabilise for >1day before consistent spectra can be collected. This has been backed up with variance studies of total pressure against spectral response. As the variance is across the whole spectrum it does offer the opportunity to easily correct the spectra using either a correct algorithm (which can be a function of the total pressure) or a calibration transfer standard which will be pursued as the project develops.

A possible hardware solution would be to have a permananet vacuum on the system, and not swtich off between measurements. This would require a battery pack but also a portable turbo point that can be moved whilst in operation. We are looking at these as options.

**SINTEF**

Beyond the development of analytical instruments for hydrogen fuel QC within HyCoRA by Protea LTD, the availability of said instruments is very limited. A Hydrogen Elimation Mass Spectrometer (HEMS) has been commercially available from Power + Energy in the US. From the available marketing information, the instrument shows great promise. The instrument was presented at the ASME 12$^{th}$ Fuel Cell Conference in Boston June 2014. SINTEF has discussions with Power + Energy and it appears that significant testing for fuel impurities need be made. Instruments are currently available neither for testing nor for purchase.

### 2.1.3 WP3 Assessment of hydrogen quality variation in hydrogen refuelling stations (VTT, PT, SINTEF)

Only SINTEF had activities in WP3 in the first 6M due to delay of gas sampler from Linde.

**Task 3.1 Measurement of hydrogen quality variation in current HRS. (M01-M18) (VTT, PT, SINTEF)**

**SINTEF**

The initial activity of T3.1 was to obtain sampling instrumentation for gas and particulates. The promised 30 day lead time of the gas sampler from Linde was adjusted to five months upon order. Delivery 3.1, which documents the use the sampling instrumentation and the procedure for sampling, was requested shifted to M7 in order to allow for testing of the instrument upon arrival in October 2014. This request has been approved. The particle sampler has been tested at a HRS in Oslo.

The first measurement campaign is thoroughly planned. With a goal of sampling from HRS's with as diverse as possible feedstock, eight HRS's in Hamburg and Berlin were chosen. Initial collaboration with CEP has been very positive. Although the strategy for samplign has been to not to be dependent on help from operators, CEP has assured the full support from Linde, Vattenfall, Total and Shell on this sampling campaign. Especially useful is their offer to provide fuel cell vehicles for sampling. Whereas the initial plan was to travel from Oslo to Kiel in a MB F-Cell, the plan culminated as with the rejection of a hydrogen fuelled vehicle by Color Line. CEP fuel cell vehicles will therefore be used. The sampling campaign is scheduled for November 2014.

A considerable effort has been put into aquisition of feasible sample containers for this purpose. Due to the pre-concentration efforts of WP2 as well as distrution of samples between the partners of the project, a larger sample volume is required. Obtaining sample canisters for this purpose has been challenging. There are various types of passivation available and their performance in this application is not available information. The purchased 10 L Spectraseal cylinders from Linde, fitted with Stainless Steel valves, is – despite a higher cost than initially budgeted – believed to be the best available alternative for HyCoRA WP3 activities on the market today.

The sampling strategy for WP3 first sampling campaign will be presented at the first HyCoRA OEM Workshop in Brussels, Nov 30.

The established collaboration with ANL on pre-concentration methodology has pushed the testing of palladium membrane pre-concentration forward.

The promised assistance of HRS operators in Norway (HYOP) and Germany (CEP) for sampling from refuelling station is very promising when it comes to the project resources required per HRS sample collected.

### 2.1.4 WP4 Risk assessment of hydrogen quality assurance failure (VTT, CEA, JRC, PT, SINTEF, PC)

Only VTT is reporting in this WP, as the work from the partners is advisory type.

#### Task 4.1 Development of qualitative risk model (M03-M07)

The work was started in M5 according to the project plan. Deliverable D1.1 of WP1 was reviewed to improve understanding of the state-of –art and the main factors affecting PEMFC performance. Also a brief literature review of hydrogen production and purification methods was conducted.

Development of the first risk model versions was started around a relevant example case with limited scope. Hydrogen produced centrally from natural gas (NG) by steam reforming (SR) and purified by pressure swing adsorption (PSA), and carbon monoxide (CO) as single significant contaminant was selected as the starting case for the risk modelling.

Initial influence diagram models for considering the risk of FCEV performance degradation due to CO contamination in the fuel and CO contamination in HRS dispensed fuel produced by off-site NG-RS-PSA process have been introduced.

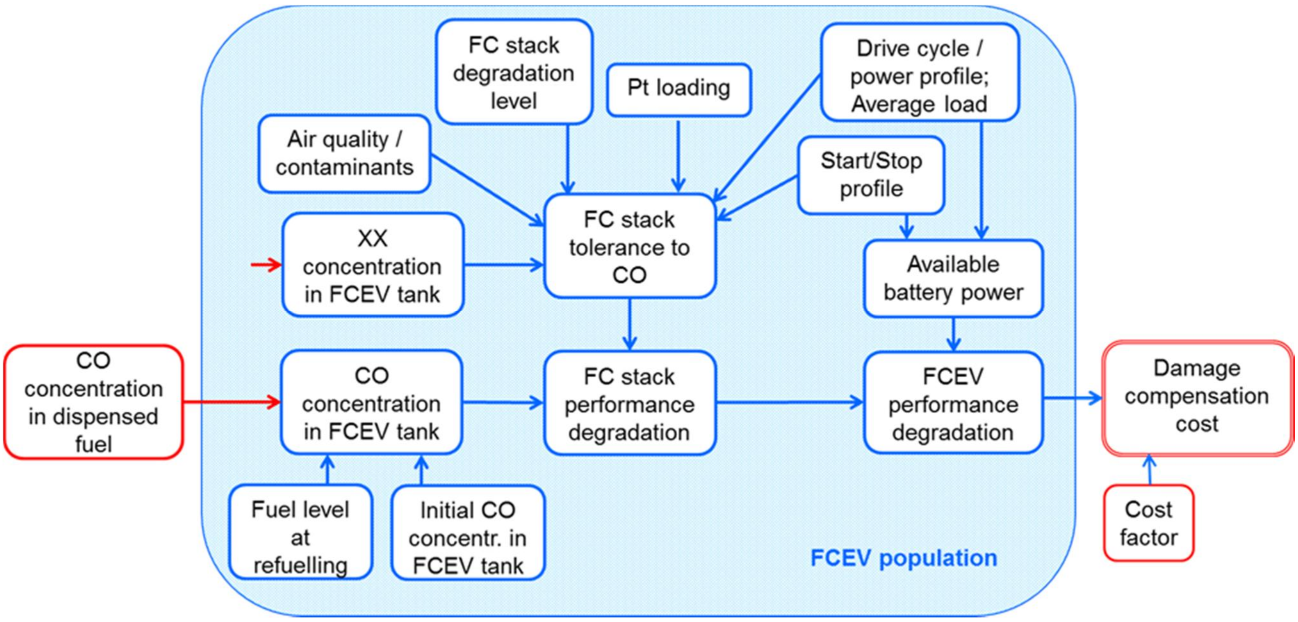



Figure 2.10 Tentative ID model for FCEV performance degradation due to CO contamination in fuel

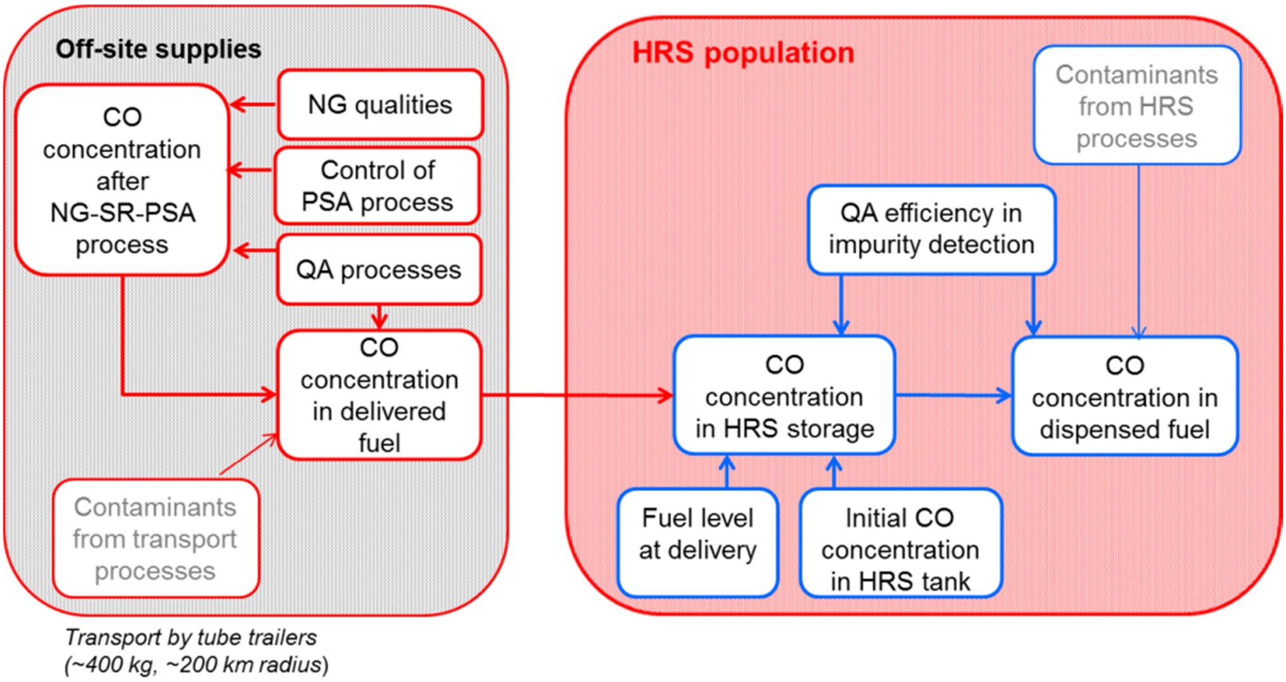



Figure 2.11 Tentative ID model for CO contamination in HRS dispensed fuel

**Task 4.2 Development of quantitative model for risk assessment (M05-M24)**

Building a Bayesian network (BN) model for the selected example case (central NG-SR-PSA production process; CO as single impurity) has been started. First version of the model is produced for introduction in the OEM Workshop 1. The model development continues taking into account the feedback and inputs from the OEM Workshop.

**Task 4.3 Risk assessment of QA concepts for hydrogen fuel quality (M05-M34)**

The task has not started yet. It can commence once the quantitative model developed in Task 4.2 is available.

### 2.1.5 WP5 Dissemination, recommendations and communications (VTT, CEA, JRC, PT, SINTEF, PC)

General dissemination activities are reported in the beginning of this section. In Task level only JRC is reporting it's activities.

**VTT**

VTT presented the project and first results in International Workshop on PEMFC Stack and Stack Component Testing Testing Procedures in Industry and Academia 3rd and 4th of June 2014 STEP – Conference Center, Stuttgart

**CEA**

The project has been presented to M. Fabien Heurtaux (Renault) and to M. Rod Borup (Los Alamos)

**SINTEF**

At the ASME 12th Fuel Cell Conference in Boston June 2014, SINTEF had discussions with DOE administrative representatives and a large interest for the HyCoRA project was noted. Visiting ANL a few days later, collaboration between DOE/ANL and HyCoRA had been promoted by the director of the DOE Hydrogen Programme. A list of possible collaboration topics has been proposed. ANL has requested access to the public QC data generated by HyCoRA. ANL has previously published fuel composition modelling efforts that could provide useful for the project. ANL will visit SINTEF Sept 26. and 29., and present their work on pre-concentration of samples at the HyCoRA OEM workshop in Brussels Sept. 30.

Discussions with the Technical Director of the California Fuel Cell partnership during the ASME Fuel cell conference on the topic of sharing results from HRS QC was very fruitful. This has been forwarded to DOE as a possible point of collaboration.

**JRC**

**Task 5.1: Interaction with OEM advisory board (M01-M36)**

Invitations to known contacts of several OEM organisations including automotive companies and fuel / gas suppliers for the establishment of an industrial advisory board (IAB) to assist project execution, in particular, feedback collection were sent.

Some communicated their interest to join the board once they have obtained approval by their management in particular automotive OEMs. A few other organisations would await the attendance of the first OEM workshop before making a decision on IAB participation.

**Task 5.2 Organization of OEM workshops**

As for the IAB invitations, OEM were invited to attend the first workshop entitled “Hydrogen Fuel Quality Assurance for PEM Fuel Cells – Needs & Status, OEM workshop supporting risk assessment” to beheld in Brussels on 30 September 2014. The workshop is to identifying critical needs to develop nozzle sampling methods and hydrogen contaminant analysis tools through data collection and modelling guiding research in this project regarding the impact on PEM fuel cells of hydrogen fuel contaminants by qualitative and quantitative risk assessment.

The collection of OEM feedback and support is vital for the success of this workshop to identify issues requiring most attention before extensive research can be conducted in this project.

A selected number of attendees from the partners and participating OEMs will give presentations to support the risk assessment by summarising the state-of-the-art and stipulating a panel discussion allowing OEMs to express their views and to provide feedback.

While the workshop agenda, venue and planning is in common agreement with the involved partners, the logistics of it is handled by JRC.

## 2.2 Deviations and impact

### 2.2.1 VTT

There have not been any major deviations in VTT activity from Annex I.

### 2.2.2 CEA

In the first 6 month, most of the technical work has been dedicated on the implementation/monitoring of the recirculation loop. The use of recirculation loop is still to be optimized and validated. Test under CO containing H2 has not started yet.

The validation of the cuurent cycle to use in the project will be done during the first OEM work shop. After that, the reference test under pure H2 and CO containing H2 could be start.

### 2.2.3 JRC

At JRC, hardware functionality tests to calibrate the MS analyzer will continue beyond M08 upon equipment maintenance.

### 2.2.4 Protea

There has not been any major deviations in VTT activity from Annex I

### 2.2.5 SINTEF

Lead time of gas sampler from Linde was changed from 30 days to 5 months upon purchase. This has delayed the execution of the first HRS sampling campaign. As testing and documentation of the sampling unit is part of the D3.1, this delivery had to be delayed from M4 to M7. This delay has been approved by the commission.

### 2.2.6 Powercell Sweden

The stack deliveries have been delayed due to lead time issues with suppliers. The first stack has now been delivered to VTT Finland for integration in their miniature automotive system test bench.

### 2.2.7 Summary of deviations and overall impact on the work

The work in WP1, especially in Task 1.2 has started unevenly. VTT and CEA have consumed resources as planned, as seen in use of resources. VTT has completed the work in Task 1.2 and CEA is well on the way. JRC has not been able to start the work as planned, which is also seen in use of resources. The delay in Powercell S2 stack delivery has not influenced the work of other partners due to other delays.

In WP3 the delay of sampling unit has not had any major delay for the work, as the time could have been used for the mapping of available HRS as well as planning of the sampling work.

## 2.3 The use of resources

### 2.3.1 Deviations between actual and planned person-months per work package and per beneficiary in Annex 1

In WP1 the use of resources has been uneven, as seen in the following table. VTT and CEA have consumed resources as planned or faster, while JRC has had a slow start. Powercell has started as expected, since the main delivery of the stacks will be later in the project.

| WP1 | VTT | CEA | JRC | POWERCELL |
|---|---|---|---|---|
| Actual PM | 7,4 | 11,2 | 1,0 | 2,1 |
| Budget PM | 17,0 | 40,0 | 16,0 | 10,5 |
| WP % of total PM | 43,2 % | 28,1 % | 6,3 % | 20,2 % |
| WP % of total Budget | 30,3 % | 24,4 % | 2,7 % | 10,1 % |

In WP2 the work has been started mostly as planned. The start of Protea has been slightly low, while CEA has already consumed almost 40% of it's budget.

| WP2 | VTT | CEA | PROTEA | SINTEF |
|---|---|---|---|---|
| Actual PM | 1,7 | 1,1 | 1,3 | 1,6 |
| Budget PM | 12,0 | 4,0 | 24,0 | 10,0 |
| WP % of total PM | 13,8 % | 27,3 % | 5,3 % | 16,3 % |
| WP % of total Budget | 18,4 % | 38,2 % | 4,9 % | 13,2 % |

In WP3 the sampling campaign work has not really been started due to delay of the sampling device. Correspondingly, the activity has been low.

| WP3 | VTT | PROTEA | SINTEF |
|---|---|---|---|
| Actual PM | 0,0 | 0,0 | 2,3 |
| Budget PM | 3,0 | 1,5 | 20,0 |
| WP % of total PM | 0,0 % | 0,0 % | 11,3 % |
| WP % of total Budget | 0,0 % | 0,0 % | 8,9 % |

WP4 work has been progresses as planned, which is seen also in the PM and budget of VTT.

| WP4 | VTT | CEA | JRC | PROTEA | SINTEF | POWERCELL |
|---|---|---|---|---|---|---|
| Actual PM | 1,5 | 0,0 | 0,0 | 0,0 | 0,1 | 0,0 |
| Budget PM | 12,0 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 |
| WP % of total PM | 12,1 % | 0,0 % | 0,0 % | 0,0 % | 20,0 % | 0,0 % |
| WP % of total Budget | 12,8 % | 0,0 % | 0,0 % | 0,0 % | 13,9 % | 0,0 % |

In dissemination WP5 there have been very little activities in the beginning of the project, as planned.

| WP5 | VTT | CEA | JRC | PROTEA | SINTEF | POWERCELL |
|---|---|---|---|---|---|---|
| Actual PM | 0,0 | 0,0 | 0,4 | 0,0 | 0,1 | 0,0 |
| Budget PM | 1,0 | 1,0 | 4,0 | 1,0 | 1,0 | 1,0 |
| WP % of total PM | 0,0 % | 0,0 % | 8,8 % | 0,0 % | 6,0 % | 0,0 % |
| WP % of total Budget | 0,0 % | 0,0 % | 12,4 % | 0,0 % | 4,1 % | 0,0 % |

In management WP6 the work has been as planned, which is seen in PM.

| WP6 | VTT |
|---|---|
| Actual PM | 2,0 |
| Budget PM | 9,0 |
| WP % of total PM | 22,3 % |
| WP % of total Budget | 18,1 % |

All in all, the project work has started slightly unevenly as the main part of the work is at different stages for each partner. This is seen in the overall PM and Budget.

| TOTAL PROJECT | VTT | CEA | JRC | PROTEA | SINTEF | POWERCELL |
|---|---|---|---|---|---|---|
| Actual PM | 12,5 | 12,3 | 1,4 | 1,3 | 4,1 | 2,1 |
| Budget PM | 54,0 | 45,5 | 20,5 | 27,0 | 31,5 | 12,0 |
| WP % of total PM | 23,1 % | 27,1 % | 6,6 % | 4,7 % | 12,9 % | 17,7 % |
| WP % of total Budget | 19,8 % | 25,1 % | 3,7 % | 4,5 % | 10,1 % | 9,3 % |

### 2.3.2 Corrective actions proposed

The main delays are due to late delivery of sampling device in WP3 and slow start of the JRC work in WP1.

When the sampling device arrives in M7, the work in WP3 can start with full power. No additional corrective actions are needed.

In WP1 a short researcher visit from VTT to JRC is planned for 21.10.2014 and 23.10.2014 for demonstrating the use and benefits of anode recirculation system. With this support, JRC should have a good kick-start for the WP1 work.

# 3. Project management during the period

## 3.1 Consortium management tasks and achievements

The start date for the project was 1st of April 2011. The kick-off meeting was organized by VTT in Espoo in the 8th and 9th of April 2014. During the kick-off also the technical work of WP1-WP2 were launched. Kick-off report has been submitted (Deliverable 6.1).

The first progress meeting was organised in Brussels 29th of September 2014. Minutes of the meeting has been delivered for the consortium members.

## 3.2 Problems which have occurred and envisaged solutions

The problems in the technical work have been the uneven start of the WP1 and delay of sampling device delivery. The solutions are proposed in Chapters 2.2 and 2.3.

The consortium agreement is still not signed due to numerous requests for changes and also changes of responsible lawyer at VTT (twice).

## 3.3 List of project meetings, dates and venues

List of project plenary meetings

| Date | Place | Title |
|---|---|---|
| 8.-9.4.2014 | VTT, Espoo (Finland) | Kick-off meeting |
| 29.9.2014 | Brussels (Belgium) | 1st semi-annual project progress meeting |

The initiation and progress of the project work packages has been monitored with bimonthly www-based meetings in which WP leaders have been participated.

## 3.4 Project planning and status

Project planning is progressed as expected. The guidance from OEMs in the 1st workshop was for great help and will be taken into account in WP1 and WP2 work.

## 3.5 Impact of possible deviations from the planned milestones and deliverables

There has been following deviation from the milestones and deliverables.

- D1.2 and MS12 will be delayed by at least one month.
- D3.1 and MS31 will be delayed by three months.

There delays and corrective actions have been explained in Chapter 2.2 and 2.3

## 3.6 Development of the Project website

The public web-site for the project has been opened and reported (Deliverable 6.8). The address is http://hycora.eu/

In addition to public web-site, a restricted SharePoint work area has been created for the consortium members.