VOLUMETRIQ

VOLUME MANUFACTURING OF PEMFC STACKS FOR TRANSPORTATION AND IN-LINE QUALITY ASSURANCE

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***Project Coordinator**: Ashley Kells – Intelligent Energy*

DELIVERABLE REPORT

D2.1 – STACK REQUIREMENTS PROVIDED FOR FURTHER COMPONENT ANALYSIS	
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DISSEMINATION LEVEL		
PU	*Public*	***X***
PP	*Restricted to other programme participants (including the Commission Services)*	
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NATURE OF THE DELIVERABLE		
R	*Report*	***X***
P	*Prototype*	
D	*Demonstrator*	
O	*Other*	

SUMMARY	
Keywords	*Stack requirements specification, Performance, Geometry, Safety*
Abstract	*This deliverable concerns a set of fuel cell stack requirements which have been derived from vehicle specifications defined by the OEMs. The project target is to build a fuel cell stack of 90 kW continuous power at specific operating conditions as described in this report. The requirement specifications will be used to further breakdown the necessary component properties in order to fulfil the general system requirements.*

REVISIONS			
Version	**Date**	**Changed by**	**Comments**
0.1	27th November 2015	Z. Veziridis, BMW	

STACK REQUIREMENTS PROVIDED FOR FURTHER COMPONENT ANALYSIS

CONTENTS

1 INTRODUCTION

The fuel cell stack specifications described herein are derived from performance targets of a conceptual fuel cell vehicle. The performance targets are broken down to stack requirements including geometry, weight, operating conditions and safety. The vehicle requirements provide a starting point, which are cascaded down from powertrain to system to fuel cell component requirements. This approach is illustrated in the following figure 1.

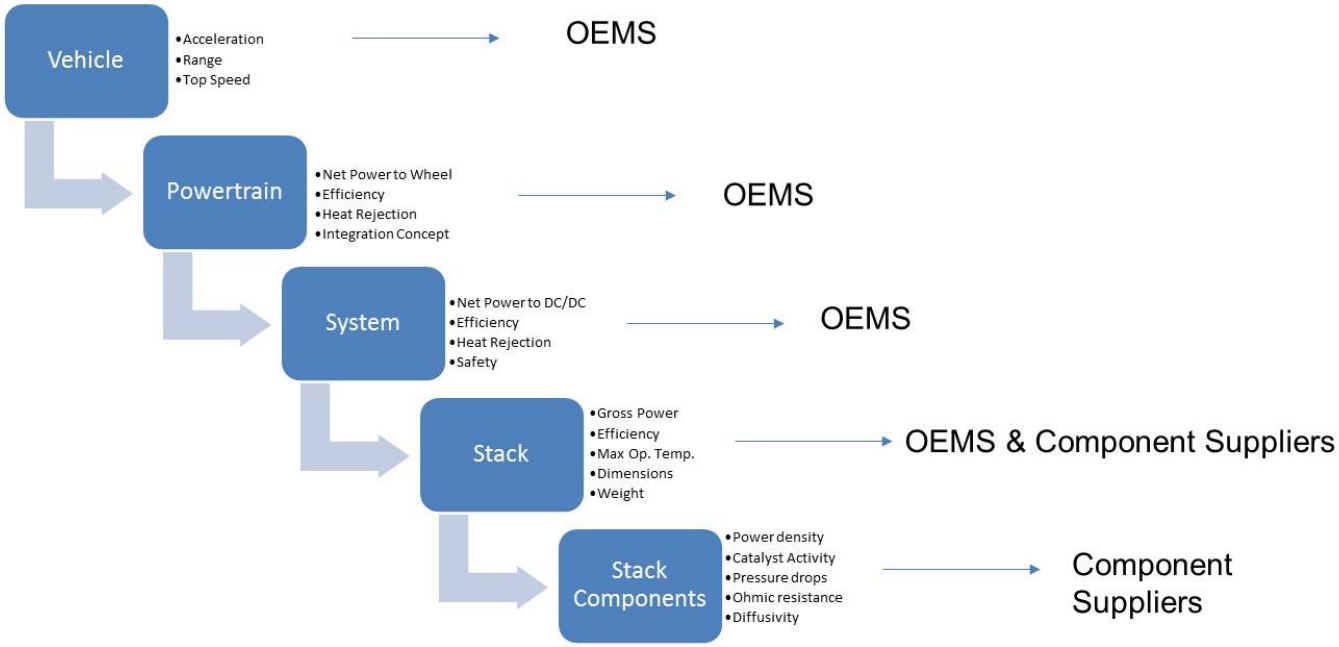

Figure 1: schematic of the requirements development starting from vehicle specifications.

The set of requirements described below has been discussed with the consortium partners and iterated to reach an agreement which is acceptable to the stack and component manufacturers.

2 SCOPE

The scope of this report is to present stack and component requirements that meet automotive standards. These will be used as a basis for a detailed component specifications like, for example, the bipolar plate (BPP) including sealant and coating as well as the membrane electrode assembly (MEA) including catalyst layer, gas diffusion layer (GDL) and membrane. Additional stack components that will be designed to build a complete fuel cell stack are:

- Housing and compression hardware
- Ventilation covers
- Terminals
- End plates
- Current collectors
- Insulation and sealant
- Any internal stack module wiring

Balance of plant components like air supply, valves, pumps, sensors and a cell voltage monitoring system are not in the scope of the specifications list. They are considered as part of the system requirements.

3 DISCUSSION

3.1 Parts and Interfaces Description

The assumed fuel cell system layout that is the basis for the development of the set of requirements is shown in figure 2.

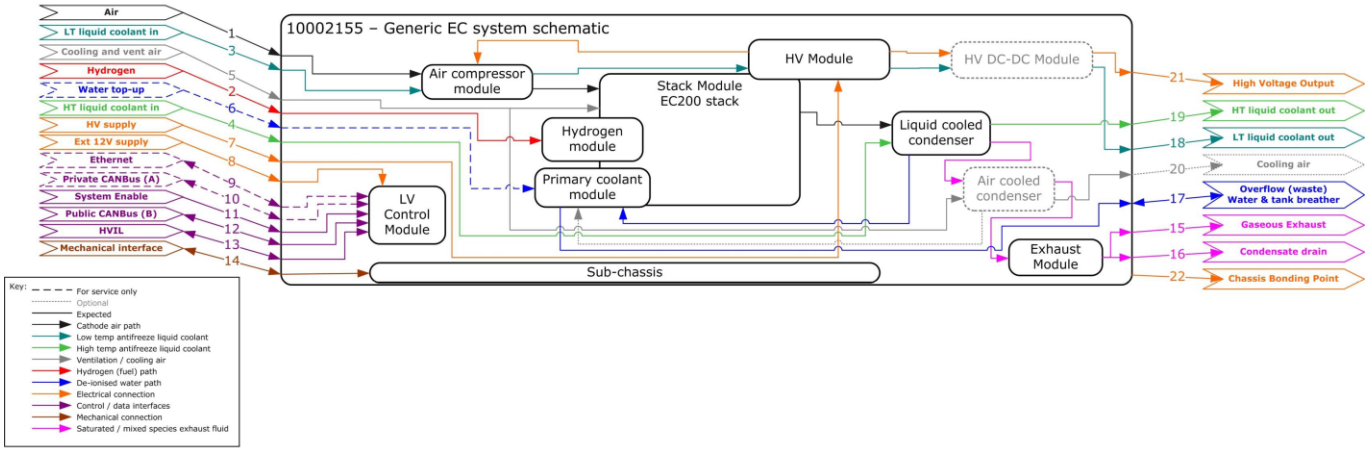

Figure 2: System schematic of fuel cell system

This system layout also shows a compressor for air supply, a coolant loop and media distribution modules. The operating conditions and properties of this configuration is assumed to be consistent with the required operating conditions and stack specifications.

3.2 General stack requirements

Some of the stack performance targets have been pre-set by the VolumetriQ project, such as current density or degradation rate. Considering the project targets and a specific vehicle system layout combined with acceleration demand, a set of general stack requirements has been developed as listed in the following Table 1. More detailed data will be derived and shared with the consortium partners than are shown in Table 1 in order to exchange sufficient requirements and interface descriptions required for stack component development. The fuel cell stack requirements are considered at the stack beginning of life (BoL) status, directly after manufacturing and conditioning.
During an End-of-Line test procedure several tests need to be performed to ensure that the stack is operational and the performance lies between the set values. The End-of-Line test sequences are:

- Leakage test

- HV- compliance test
- Pressure drop cooling loop (max.)
- Pressure drop anode (max. flow)
- Pressure drop cathode (max. flow)
- OCV hold test
- Cell voltage deviation at continuous power (90 kW at 85°C)
- Peak power depending on conditioning status (30 s at 95 °C stack outlet)

The duration of the EoL-test is a cost factor and shall be in the range of 30 min, but at this stage, it is not finalised.

Table 1: Stack performance requirements
Beginning of Life (BOL)

Specifications	Unit	Value	Remarks
Electrical Requirements			
Stack maximum continuous power (at 95 °C outlet temp.)	kW	90	At 35°C ambient temp.
Stack peak power (30 seconds)	kW	120	Necessary to achieve acceleration
Stack open circuit voltage (OCV)	V	< 430	
Minimum stack voltage at peak power	V	>230	
Average single cell voltage at stack peak power	V	0,6	
Current density at stack peak power	A/cm²	2,5	
Cooling Requirements			
Stack maximum outlet temperature	°C	95	
Cooling liquid	-	DI Water	
Cathode Requirements			
Anode Requirements			
H2 quality	-	SAE2719	
Durability/Reliability			
Start/stop cycles	#	150000	
Start up/Shut down cycles	#	35000	key on /key off incl. Shut down procedure (dry off, air/air start)
Max peak power degradation after 5,000 hours	%	10	10 % power loss after 10 years of operation (incl. Drive cycle)
Freeze start time (-25 °C) duration from 0 - 50 % nom. Power	s	60	
Cold start (0 to 25 °C) duration from 0 - 90 % nom power	s	30	

Warm start (> 25 °C) duration from 0 - 90 % nom power	s	15	
Operation at temperature range	°C	-40 to 95	Ambient temp.
Storage temperature range	°C	-40 to 85	
Stack cost target @ 30 000 vehicles /year	€/kW	50 - 100	FCH JU target is 100 €/kW. 50 €/kW more attractive target.

A reference polarisation curve, indicating the performance of the fuel cell stack is shown in figure 3.

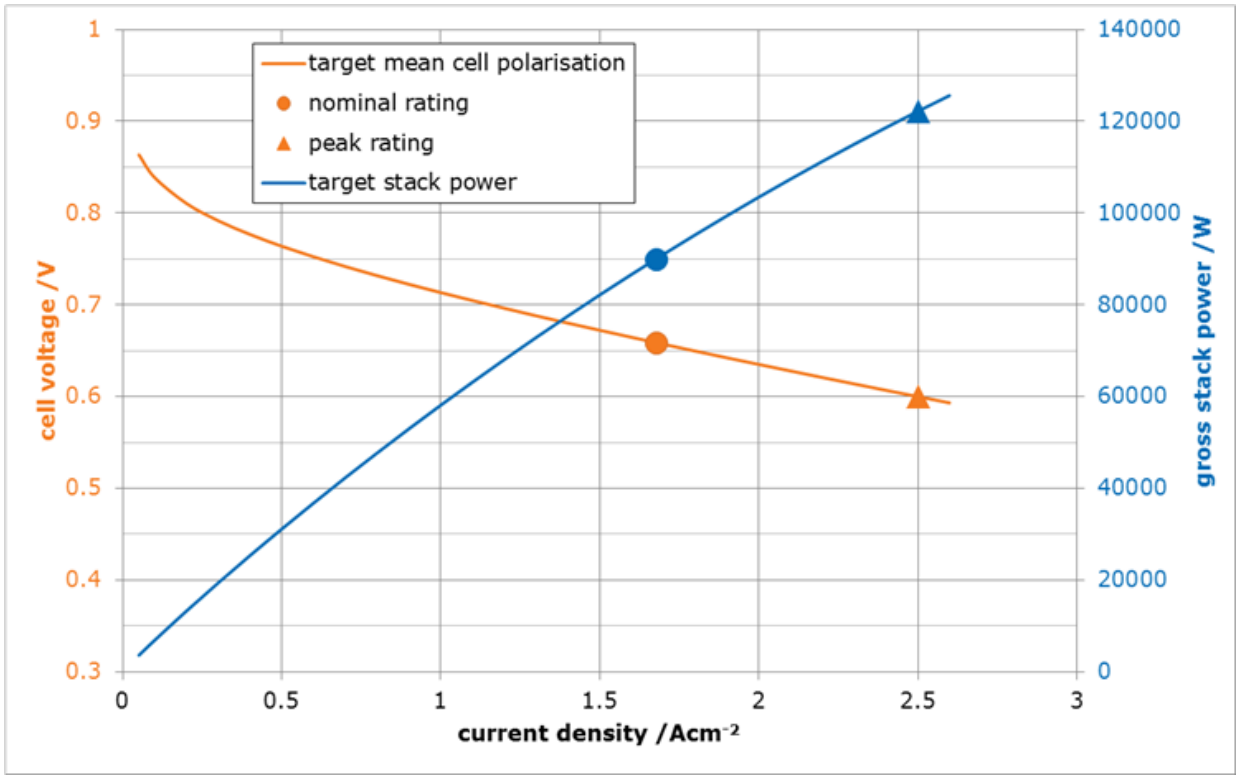

Figure 3: reference polarisation curve showing performance target

3.3 Geometric Requirements and safety

The fuel cell stack needs to fit into a specific vehicle package that defines the geometry of the stack as well as the position and orientation of terminals and interfaces. The vehicle requirements also include safety targets like electrical isolation values and hydrogen leakage rates. These values are listed in table 2.

Table 2: Stack dimensions, mechanical integrity and safety	column 1	column 2	column 3
Specifications	**Unit**	**Value**	**Remark**
Stack dimensions x direction	mm	490	Including stack case/housing
Stack dimensions y direction	mm	605	
Stack dimensions z direction	mm	190	
Possible inclination in parking and driving position	°	18	according to 32 % slope in X and Y direction
Stack weight	kg	< 50	
Intrusion protection code	-	IP6K6K, IP6K9K and IP6K7	
Shock load in X (driving direction)	g	+-15	six times 6 ms duration
Shock load in Y (perpendicular to driving direction)	g	+-15	six times 6 ms duration
Shock load in Z (up/down direction)	g	+-30	six times 6 ms duration
High accelaration in Y	g	+- 1	for 15 s
Electrical protection	-	ISO 6469 (SAE J1766)	
Isolation resistance	MOhm	> 5	Relevant for test bench operation
H2 safety regulations	-	ISO 23273 (SAE J2578)	
Leakrate stack case / box to ambient	mg/min	0,3 mg/min	safety requirement (emerg. Shut down)

For certain requirements there are pre-defined BMW group standards (BMW GS) available that describe measuring procedures and pass/fail criteria. Those group standards will be made available to the consortium partners as needed.

The geometric requirements are also shown in figure 4, illustrating the package restrictions for the stack only and the position of the terminals that are required to fit into the vehicle interfaces.

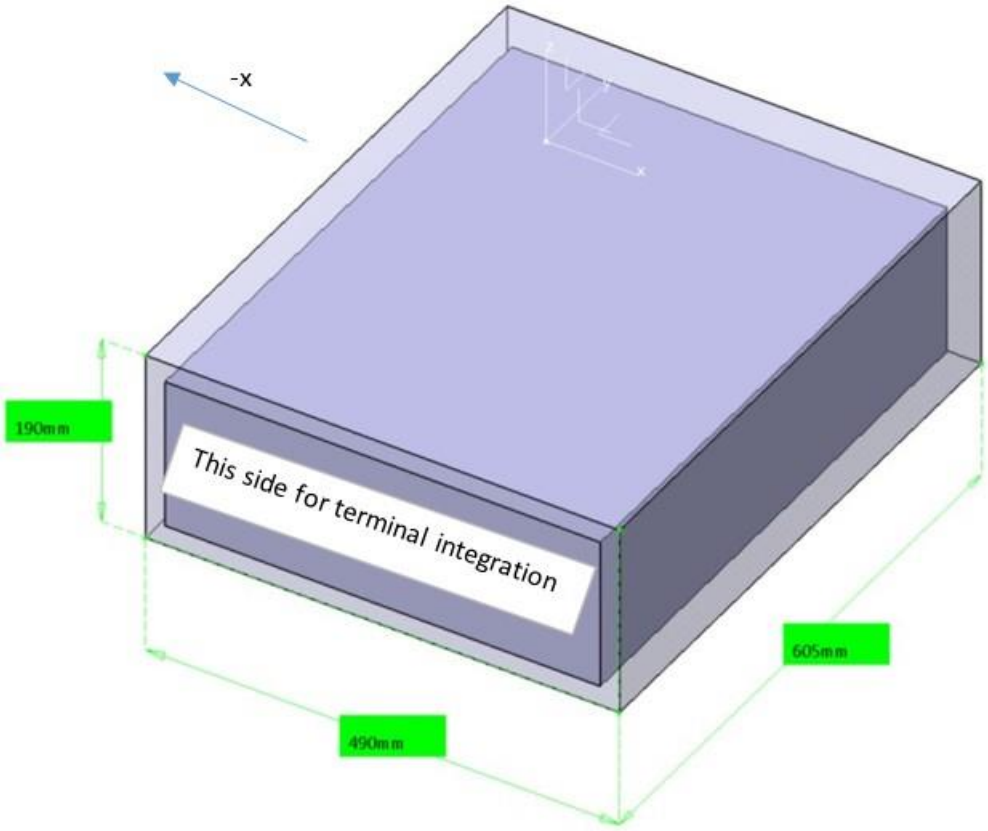

Figure 4: Fuel cell stack dimensions and position of terminals

4 CONCLUSIONS AND FUTURE WORK

General stack requirements have been presented in this report which will be used to further define and specify fuel cell stack components.
Once all stack requirements have been fixed, a complementary test requirements specification will be defined. This will ensure the verification of all requirement values that have been set. This set of test requirements will be presented in a separate report.