Deliverable D2.4

PEMFC Stack Manufacturing Cost Estimation
public summary

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Dissemination Level		
PU	Public	**X**
PP	Restricted to other programme participants (including the FCH JU)	
RE	Restricted to a group specified by the consortium (including the FCH JU)	
CO	Confidential, only for members of the consortium (including the FCH JU)	
EU restricted	Classified with the mention of the classification level restricted "EU Restricted"	
EU confidential	Classified with the mention of the classification level confidential " EU Confidential"	
EU secret	Classified with the mention of the classification level secret "EU Secret "	

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1 Objective of this deliverable

This deliverable presents the PEMFC stack cost assessment that have been done on the AUTOSTACK project based on the "Generic Designs", "Accepted Specifications" and "Standard Manufacturing Processes" worked out in Work Packages 1 and 2.

The main objectives of the deliverable are:

- To identify and show the capabilities of the European component supply industry
- To model the component options and their impact to full stack cost

2 Cost Assessment

The supply chain assessment did include cost projections for the time frame 2015 and 2020 based on the production volume assumptions shown in the following tables. For the specific power and the size of the active area of the stack, the following assumptions were used:

- 1 W/cm^2 specific power density at 0.67 V cell voltage of the MEA
- 95 kW gross stack power
- 315 cells per stack
- 300 cm^2 active area per cell.

The MEA cost estimates have been asked from the suppliers for 5-layer type MEA's with the initially proposed Pt-loading of 0.15 mg/cm^2. As Pt-reference cost, 40 €/g Pt were used. This Platinum price is different from the DTI assumption (35 $/g (equaling 25 €/g) Pt) [1], but seems more realistic observing the Platinum price history and current price level. The estimate is for per-fluorinated membranes. Cost for sealing was not included as it was chosen to be part of the bipolar plate. The cost is quoted as €/kW based on the outlined assumptions.

Production cost [per kW_{stack}]	Mean value	Lowest value	@ annual production rate [unit]	Production capacity [units]
2010	124 €	71 €	100.000	10 – 300 k/a
2015	62 €	14 €	1mill	0.1 – 1mill/a
2020	44 €	14 €	4mill	n. a.

Table 1: **Cost projections for MEAs**

A metal bipolar plate is composed of two half plates, including coating and sealing. The data in Table 2 are for a complete plate with an active area of 300 cm^2. If coating was not included in the cost quoted by the supplier, a markup of 1 €/plate was assumed. This value was derived from the TIAX study [2] which uses ~0.4 €/plate for nitrification coating process applying a more conservative approach.

Production cost* [kW_{stack}]	Mean value	Lowest value	@ annual production rate [unit]	Production capacity [units]
2010	44 €	37 €	100.000	10k – 10mill/a
2015	18 €	15 €	1mill	0.5 – 12mill/a
2020	11 €	8 €	10mill	5 – 100mill/a.

Table 2: Cost projections for metallic bipolar plates

A carbon composite bipolar plate is composed by two half plates and sealing. The data in Table 3 are for a complete plate. If sealing was not included in the cost by the supplier, an additional cost of 1.5 €/plate was assumed. This value was conservatively derived from a source within the consortium.

Production cost* [kW_{stack}]	Mean value	Lowest value	@ annual production rate [unit]	Production capacity [units]
2010	87 €	32 €	100.000	35 – 200 k/a
2015	42 €	27 €	1mill	1 – 2mill/a
2020	20 €	12 €	10mill	10 – 100mill/a

Table 3: Cost projections for carbon composite bipolar plates

Cost projections for bi-polar plates @ mass production, i.e. 10 million plates, received within the survey suggest that the cost of metallic versus carbon bipolar plates is between 33% (average) and 45% (maximum) lower. Thus metallic bipolar plates not only offer better technical properties but also cost benefits over carbon plates.

3 Cost modeling

Following the approach of the supply chain analysis, the methodology of the "Cost Evaluation Tool" was based on the core stack components having the most critical cost impact. The assumed production rates were: 1 000, 10 000, 50 000, 100 000 and 500 000 fuel cell stacks per year. Due to the lack of industrial data, a part of the production rates, i.e. those above 50 000 stacks / year could only be calculated through extrapolation of component costs by applying relevant learning curves. For reference and benchmark purposes, relevant other studies were observed. The general approach of the cost model is displayed in Figure 1, below.

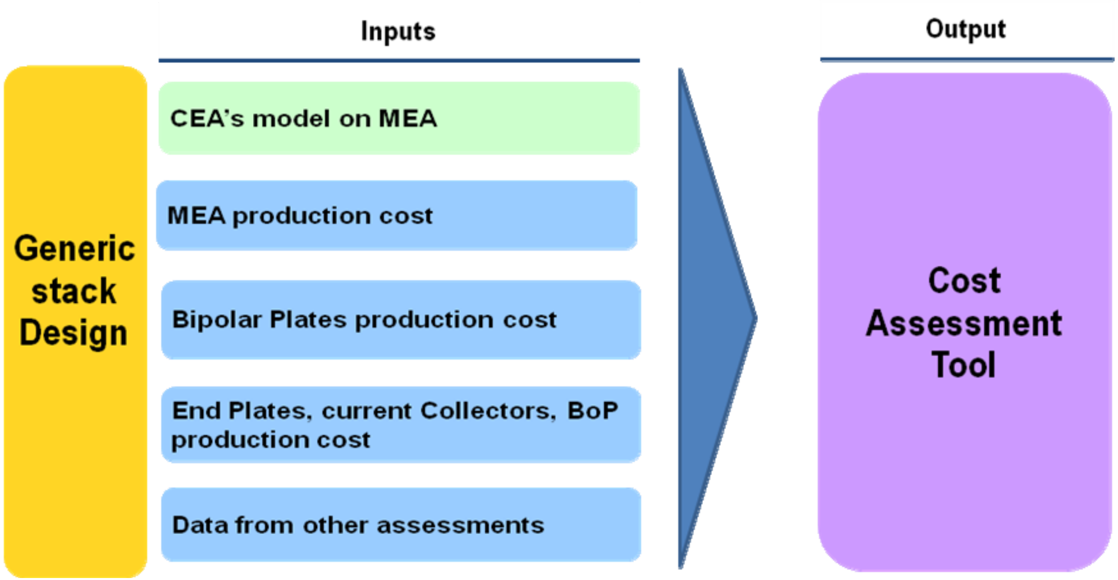

Figure 1: General approach of the cost model

The reference design for the cost analysis was chosen with a conservative approach assuming no progress of Pt-reduction in the mid-term. Along with the reference design, more challenging design options were investigated and calculated to understand the sensitivity of stack cost versus design options and different Pt-loadings.

The cost modeling confirmed the assessment of empirical data delivered by the supply chain analysis. Metallic bipolar plates deliver significant cost benefits over carbon bipolar plates establishing an advantage of ~ 27% at optimum production rates. The results of the cost analysis for the reference design are shown in Table 4, next page.

More importantly, the aggressive power density target of the Auto-Stack specification seems to providing an alternative way towards reaching automotive target cost while fully matching the performance and durability requirements. The per/kW-stack cost of € 44.00 @ 500 000 units as result of the Auto—Stack cost modeling complies very well with similar assessments such as the power-train study supported by the European Commission and a consortium of relevant automotive OEMs. Assuming a production capacity of 1 000,000 fuel cell vehicles by 2020, the stack cost was forecasted with € 43.00/ kW in this study.[1] Contrary to the Auto-Stack assumptions, the assessment was assuming very aggressive Pt-loading reductions down to a level of only 0.24 g/kW.

[1] *"A portfolio of power-trains for Europe: a fact based analysis"*, McKinsey & Company, Nov 2010, page 60

Annual production rate	1000	10000	50000	100000	500000
Total stack cost - mBPP	16 187 €	9 608 €	6 781 €	5 853 €	4 187 €
Cost/kW gross - mBPP	170 €	101 €	71 €	62 €	44 €
Total stack cost - cBPP	18 971 €	11 791 €	8 508 €	7 398 €	5 359 €
Cost/kW gross - cBPP	200 €	124 €	90 €	78 €	56 €

Power density 1 W/cm²
Pt-price @ 21,1€/g
Stack power 95 kW
Total Pt-loading 0,85 mg/cm²

Cost benefits of metallic BPP vs. Carbon BPP = 27 % @ optimum production volumes

Table 4: Results of the cost model – reference design