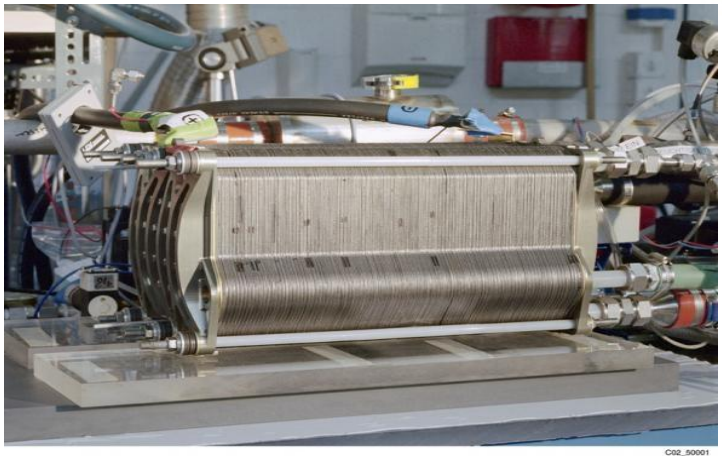
Auto-Stack: Implementing a European Automotive Stack Cluster

Contract No. FCH-JU 245142

autostack moves



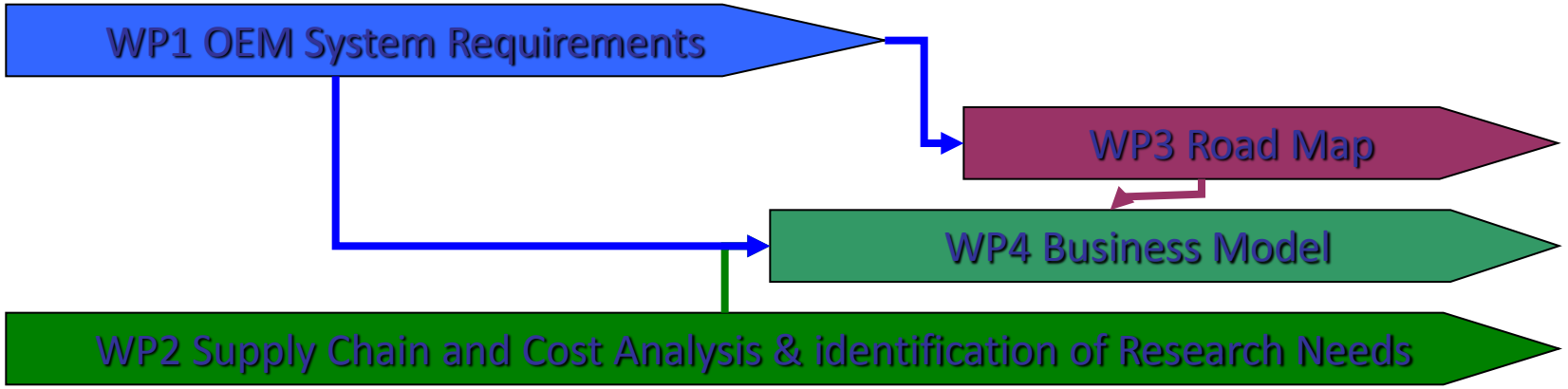
FCH-JU Program Review Day 2011, Nov 22

by André Martin and Ludwig Joerissen

Zentrum Für Sonnenenergie- und Wassserstoff-Forschung Baden-Württemberg

Scope of project to address challenge

- Development of a common OEM specification
- Assessment of the technical status of supply chain
- Conclusions for research priorities
- Analysis of synergies between applications
- Development of a business concept



Consortium combining expertise

Autostack Consortium

Automotive OEMs

Component and System Suppliers

Research Institutes

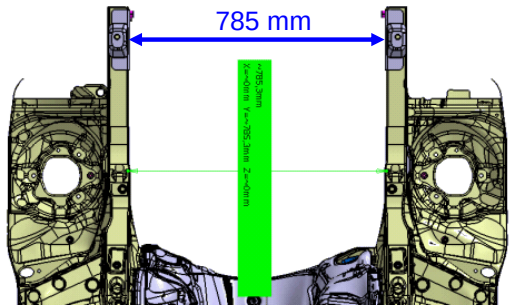
Baseline system requirements to meet

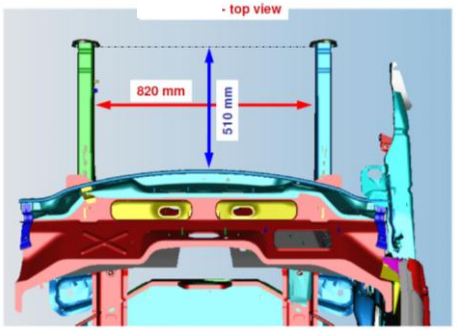
- Generally – comparable with ICE
  - Performance, dynamics
  - Gravimetric + volumetric power density
  - Cost
  - Durability, robustness, degradation
  - Cold start, cold start time
  - Limitation to one fuel only(H_2)

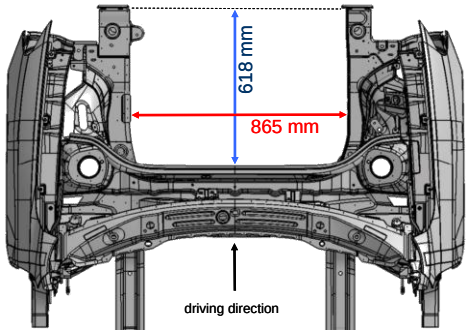
+ Superior efficiency (vs. hybrid – ICE)
+ Sustainable fuel concept

Packaging forces high power density

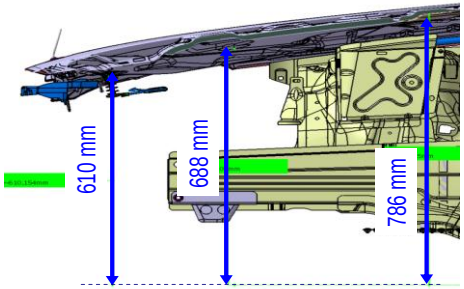
Driving direction

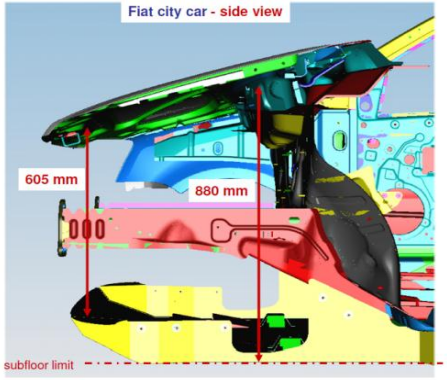


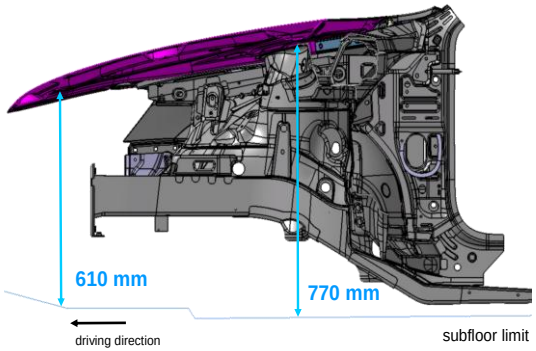




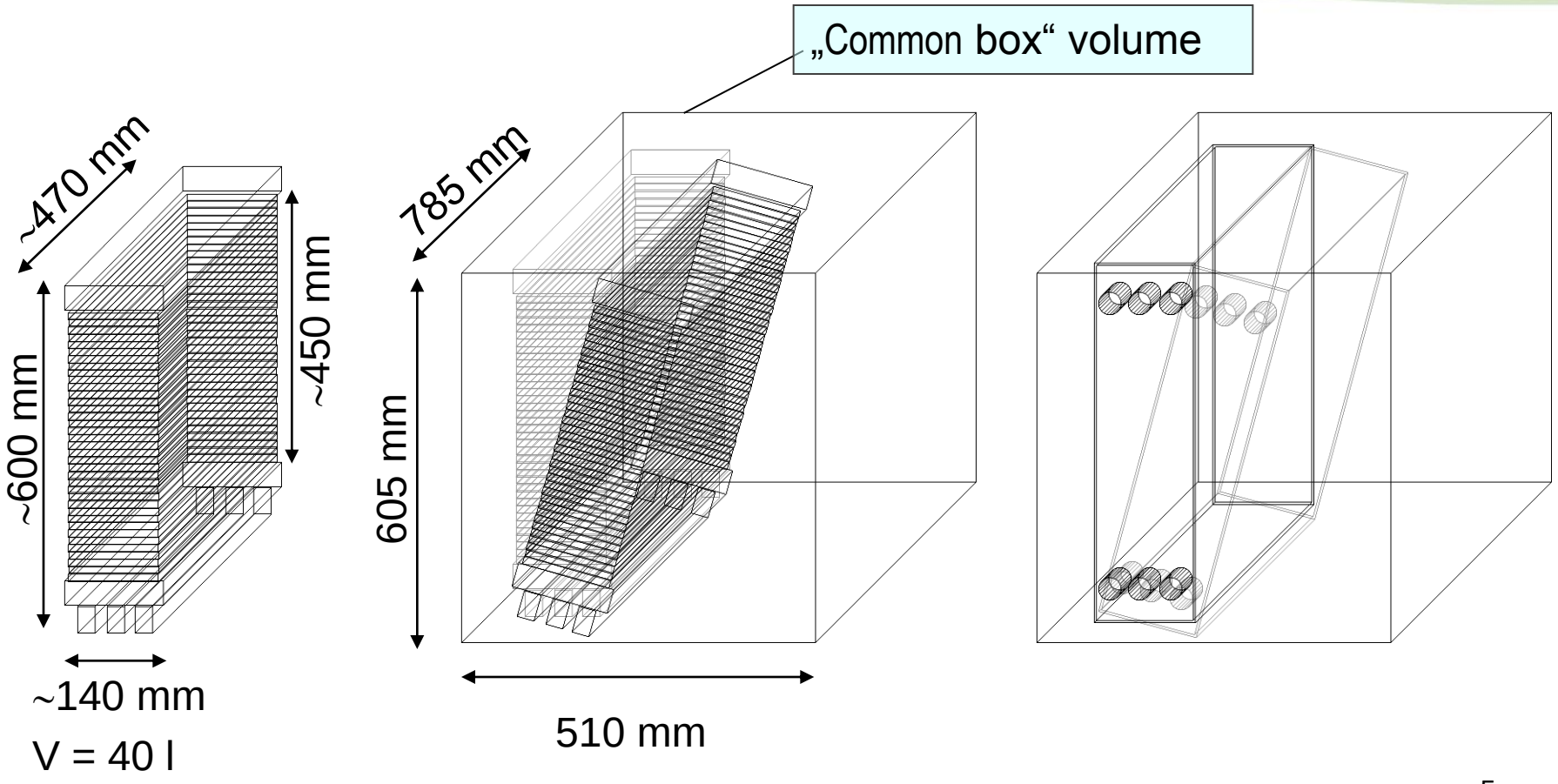
Side view







Stack needs to fit in “common box”



Focus on core components

Requirement:
Availability of industrial components until 2020 based on target specification.

- Scope of supply chain analysis was limited to MEA and bi-polar plate only as they determine performance and ~ 90% of mass production cost.
- Assessment included 54 companies with headquarters or operations in Europe.
- Thereof, 22 were considered particularly relevant. The feedback in this group was 73%.

MEA – performance does not meet target

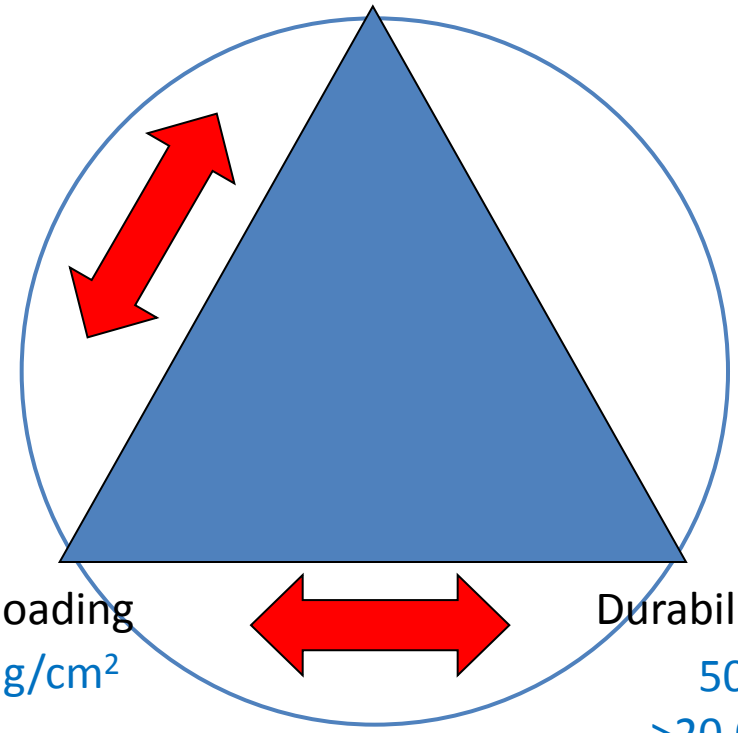
Target:
Pt-loading 0,16mg/cm² with a power density of 1,5 A/cm²@0,67 V = 1 W/cm²
observing automotive durability, robustness, degradation and efficiency

- The requirement could not be fulfilled by any of the European suppliers answering the questionnaire.
- Despite many research activities, no data were found matching this requirement.
- Reduction of Pt-loadings towards target value seems rather unlikely under industrial conditions in the mid term.
- Hence, substantially higher Pt-loadings will be required to meet technical targets.

Conflicting objectives need to be addressed

Power Density / Efficiency

1 W/cm^2 0.675 V @ 1.5 A/cm^2 / ~ 0.8 V @ 0.2 A/cm^2



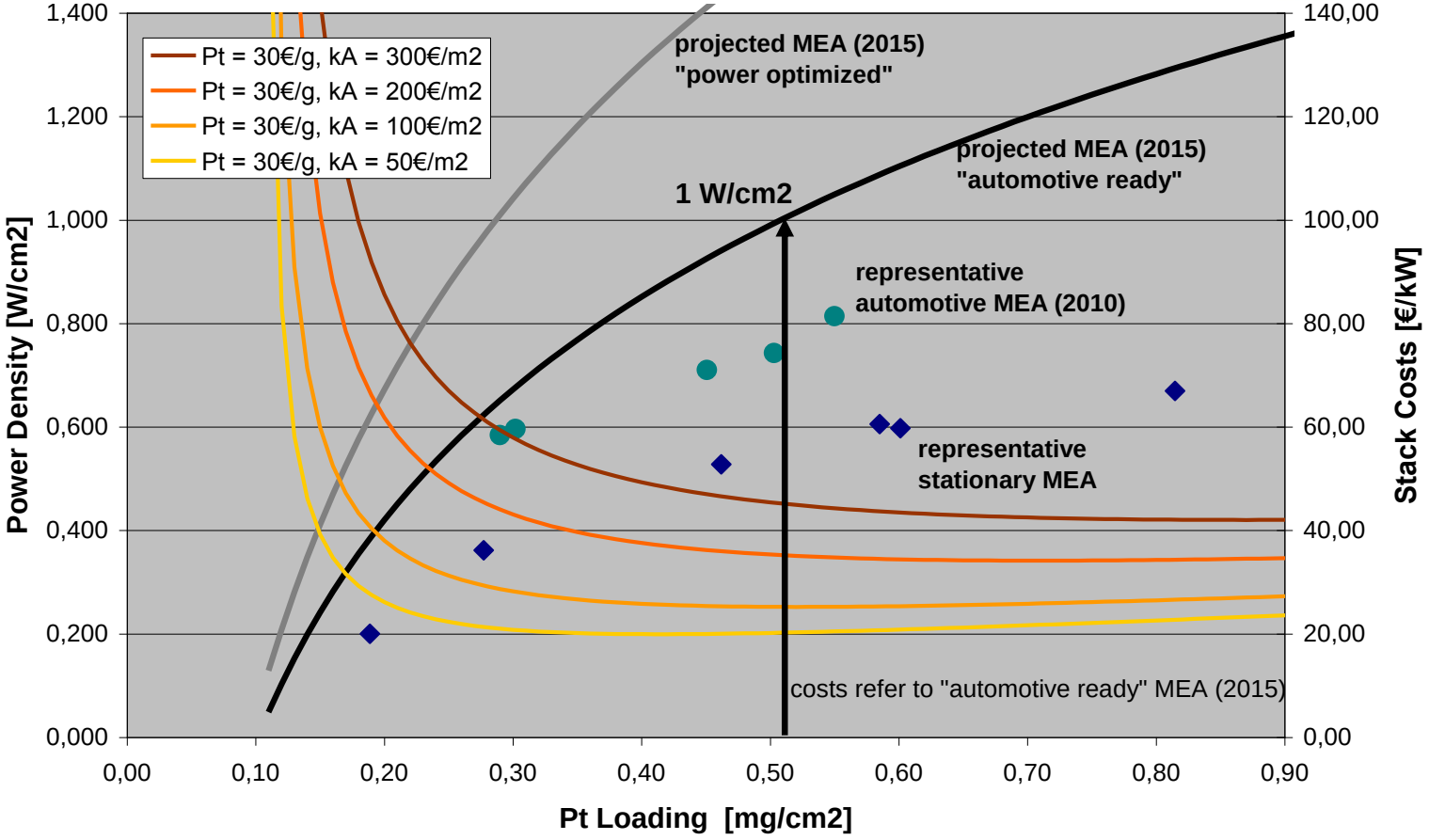
Pt loading

0,16 mg/cm^2

Durability

5000 hrs,
>20,000 starts

Balance of power density and Pt-reduction is critical



Metallic BPP offer benefits over carbon

Target:

Cell pitch < 2 mm with final target < 1.5 mm including seal

- The requirement could not be fulfilled by any of the carbon plate suppliers but by all suppliers of metallic bi-polar plates.
- However, metallic bipolar plate suppliers show a general lack of expertise in coatings and seals.
- Only one supplier offered a fully integrated BPP with sufficient technical maturity.
- Data from outside Europe suggest that carbon bipolar plates can be produced with cell pitch < 2 mm but there still remains a major gap to metallic bipolar plates.
- Cost projections for metallic bi-polar plates @ mass production (10 million units) are between 33% (average) and 45% (maximum) lower than carbon plates.

Technical choices are requested

- The assessment suggests, that high power density has to be the outstanding development target.
- This will allow to address critical packaging requirements and cost targets while still matching automotive performance, efficiency, robustness and durability.
- Reduction of Pt-loading seems to face technical limits @ 0.5 – 0.6mg/cm² based on current technology, at least until 2020.
- Metallic bipolar plates offer better potential to achieve volumetric power density and cost targets vs. carbon bipolar plates.

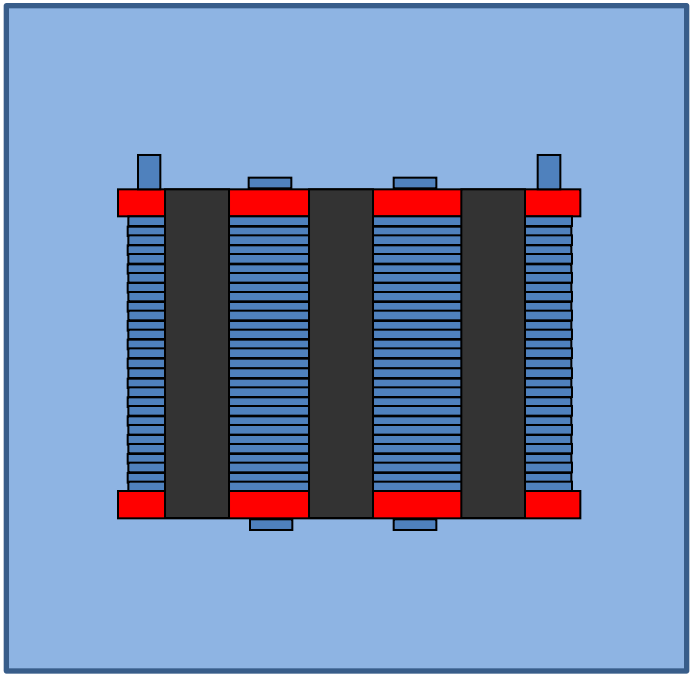
Research Topics Identified

Short Term	Mid-Term	Long Term
Integration of full size automotive stack based on Auto-Stack Roadmap.	* Development of advanced MEA with **increased power density @ 0.4 mg/cm²** Pt-loading, **lower humidification** requirements and elevated operating temperatures.	Materials research on highly active non noble metal catalyst materials for replacement of Pt-group metals.
Development of optimum power streams in fuel cell systemsto optimize the balance of fuel cell and energy storage.	* Development of advanced low cost, corrosion resistant and highly conductive bipolar plates.	Development of multi-scale modeling tool for MEA performance with focus on transport and aging phenomena.
* Development of industry wide uniform performance test schemes and commonly accepted test protocols.	* Development of characterization techniques for water management and state of health at cell and stack level.	Development of simplified system architectures and improvement of scale effects.
	Development of cell modeling for accelerated stack design with focus on critical operating parameters.	

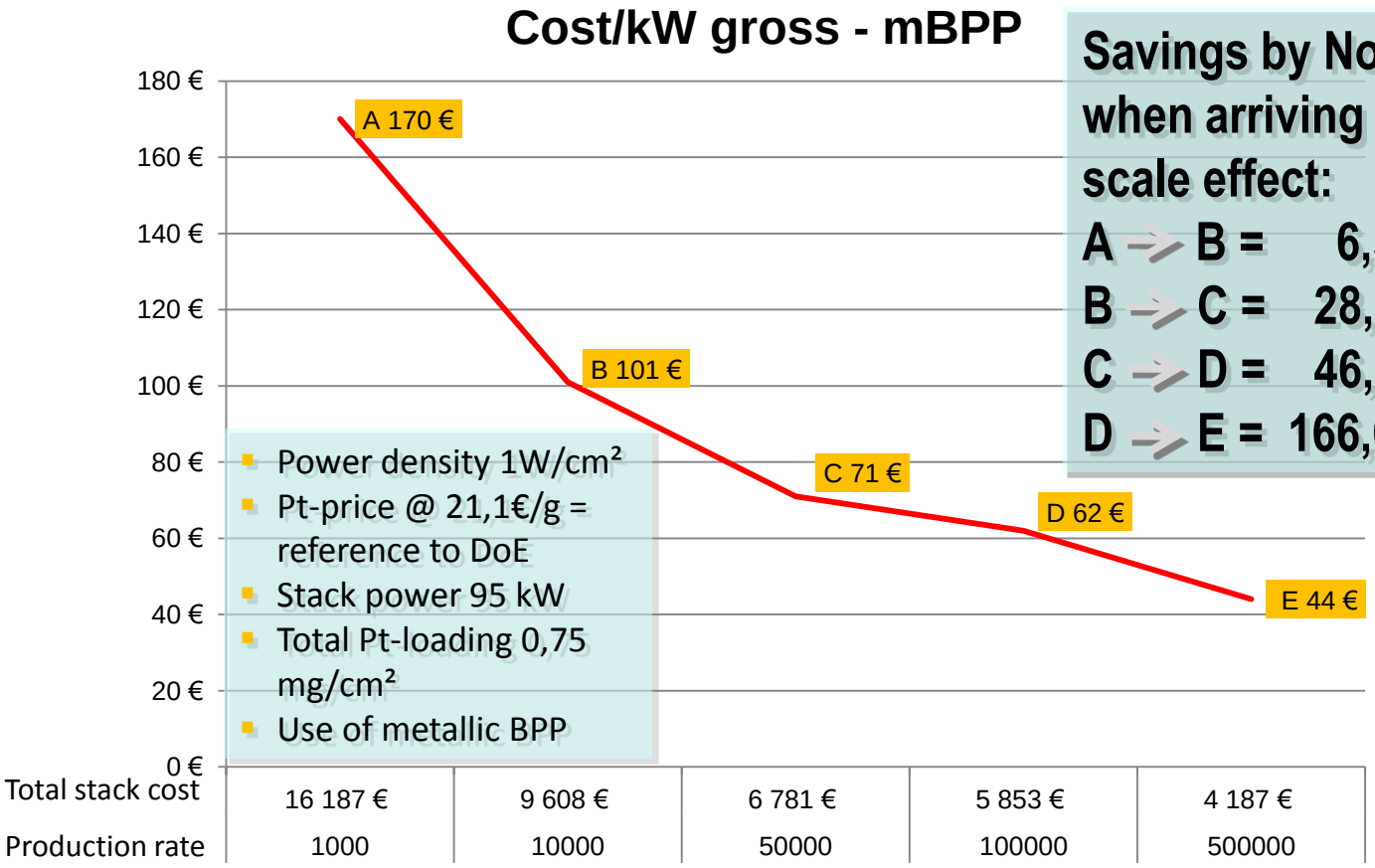
* Similar topics were already part of the 2011 call for proposals

Common OEM specification

- Power density
  - High operating point: 1,5 A/cm²@ 0,675 V/cell
  - Low operating point: 0,2 A/cm2 @ 0,8 V/cell
- Stack efficiency:
  - High power: 51 %
  - Low power: 61 %
- Pt - Loading
  - Low risk approach: < 0.6 mg/cm²
  - Medium risk approach: 0.4 mg/cm²
- Stack-power 95 kW, scalable 10 – 95 kW or multiples
- Operating Temperature < 95° C
- Operating pressure < 2 bar_a
- Voltage 220 - 430 V
- Power density (95 kW stack) < 60 l / 75 kg
- Cost 101 €/kW @ 10,000 *95 kW stacks
- Durability beyond > 5000 h



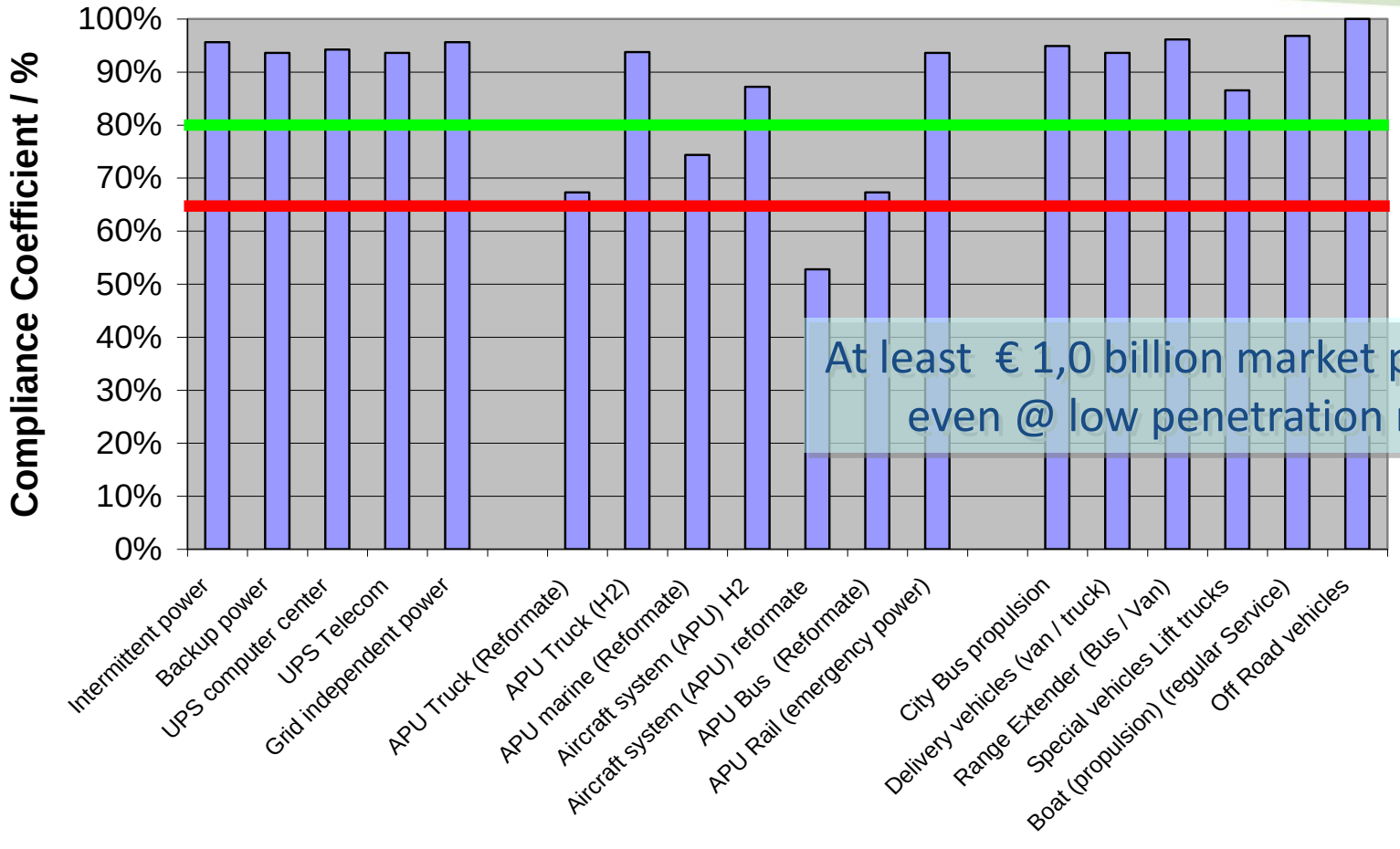
Cost analysis shows pathway to target



Savings by No. of vehicles when arriving at next level of scale effect:

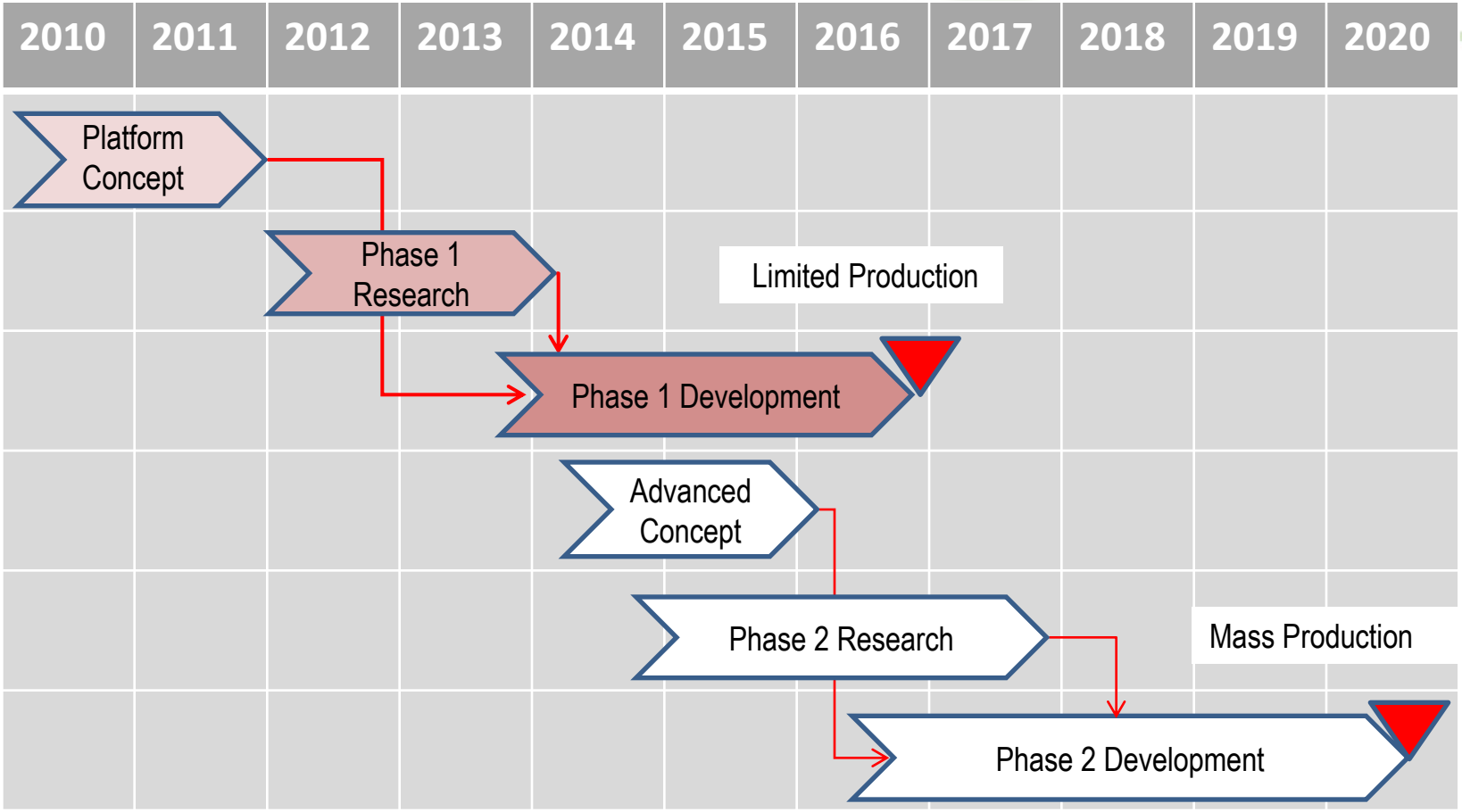
- A → B = 6,5 M€/1000
- B → C = 28,3 M€/10000
- C → D = 46,5 M€/50000
- D → E = 166,6 M€/100000

Promising compliance with other applications



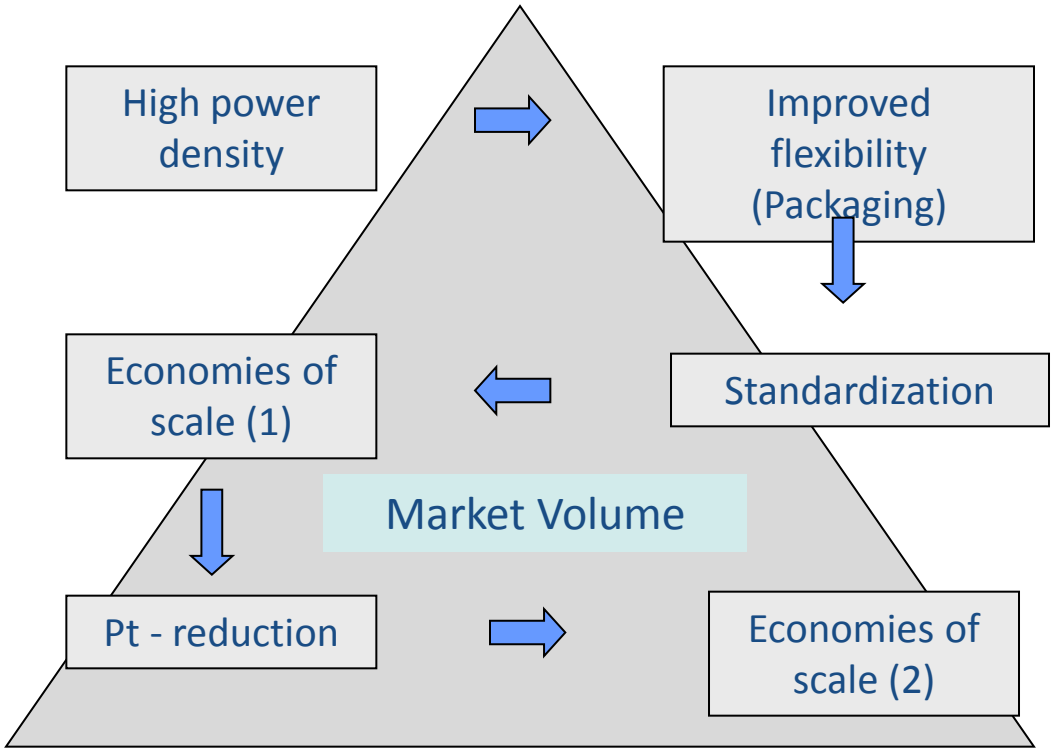
At least € 1,0 billion market potential even @ low penetration rates.

Master-plan needs 2 product iterations



Recommended two phase approach

- Mid term
  - optimization of efficiency,
  - improved catalyst utilization,
  - enhancement of robustness and durability,
- Long term
  - development of new PGM-catalysts and
  - new catalyst materials as well as
  - novel electrodes.



Consumer markets demonstrate feasibility…

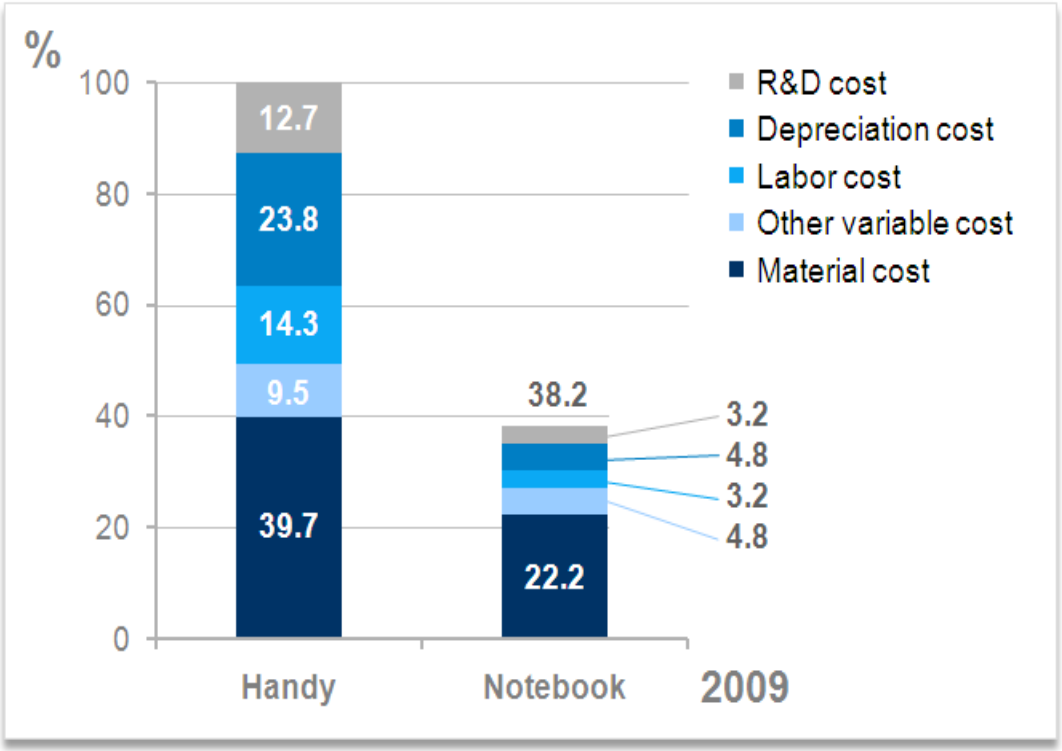
Handy

Notebook

Typical Annual Production Rates	
0.1-10 Millionen	100-300 Millionen

* Quelle: Li-ion Battery Market & Industry Trend - Goldman Sachs Japan Analyst Report – Sept. 2009

→ Relative cost of Li-Ion cells per Wh



Summary and conclusions

- Common stack platform across several OEMs appears feasible for middle class vehicles.
- High power density of the stack is key to success and for achieving cost targets.
- Metallic BPP offer substantial cost benefits over carbon BPP and are the sole option to matching the targeted volumetric and gravimetric power density.
- Automotive ready MEA-technology foreseeable in 2015 will most likely require a Pt-loading of at least 0.5-0.6 g/kW.
- The proposed platform concept offers synergies with other applications which can further improve economies of scale.
- Market introduction of fc vehicles will require massive investment before and until reaching sufficient market penetration (optimum production rates).
- A platform concept exploring synergies can help mitigate and substantially reduce market introduction cost.

AIP 2008 targets and results
Topic SP1-JTI-FCH.1.3 „European Fuel Cell Cluster“

AIP 2008 Target	Achievement
Overall scope and framework of the cluster	Agreement on general system layout and stack specification among OEM and supply chain.
Key technical, commercial and social targets	Harmonized automotive stack specification agreed, cost analysis available. Survey of the European supply industry available
Expertise, relevant players and their role and contribution to the project	European stakeholder inventory worked out, key stakeholders were project partners
Forms of collaboration between industry and research	Cooperation – competition matrix worked out for application in automotive propulsion. Research priorities defined.
Financial, resource and other requirements for success	Consistent technical road-map and ressource planning worked out.
Proposal for implementation of the project	Draft business plan available including financing options.

Thank you very much for your kind attention