FUEL CELL CLUSTER WORKSHOP

FUEL CELL TECHNOLOGY

RESEARCH AND DEVELOPMENT TOWARD INTEGRATED SYSTEM OPTIMIZATION

GÖTEBORG - JUNE 21ST, 2001

Fuel Cell Vehicle Development and Commercialization Issues

- **INFRASTRUCTURE FOR PRODUCTION AND DISTRIBUTION OF SIGNIFICANT HYDROGEN QUANTITY (2015-2020)**
- **ON BOARD HYDROGEN STORAGE ADEQUATE FOR RANGE COMPARABLE TO THAT OF CONVENTIONAL VEHICLE**
- **ON BOARD FUEL PROCESSING ADN WATER MANAGEMENT**
  - **CO CLEAN-UP (<50 ppm)**
  - **COLD START AND TIME TO FULL POWER**
  - **TRANSIENT RESPONSE**
- **AIR SUPPLY SYSTEM**

- ***ASPECT TO BE ADDRESSED***
  - ***WEIGHT, VOLUME***
  - ***INTEGRATION***
  - ***LIFE***
  - ***SAFETY***
  - ***ENERGY EFFICIENCY***
  - ***COST***

Fuel Cell Technologies Validation

- Coordinated programs with different categories of vehicles, systems and components and fuels in field operation:
  - city car,city van, multipurpose car, buses,…
  - stack, reformer, H2 storage,...
  - infrastructure for H2, fuel supply with common interfaces

- Objectives
  - vehicles and components operation assessment
  - performance evaluation efficiency assessment
  - safety aspect analysis
  - interaction with standards under definition

Proposed Programs Structure

- Initial phase of different programs should include definition of common procedure for testing operational performance and consumption.
- Safety aspect should take into account the relevant international standards(ISO TC22/SC21)which are in elaboration, for possible interactions.
- Infrastructure should be realized with commonly defined interfaces (standardization).
- Final phase of validation should include existing vehicles, activities enabling comparative assessment for both vehicles, systems, components and infrastructures.
- Intermediate results and outcomes should be transferred as a feed back at technology level

Standards for Electrically Propelled Road Vehicles
Performance and Emissions

ITEM	STANDARDIZATION BODY		INTERNATIONAL LEGAL REQUIREMENTS
	CEN	ISO	ECE / ONU
ROAD OPERATING ABILITY			
1 PURE ELECTRIC VEHICLES	EN 1821-1	8715	R.68 (Amendment)
2 THERMAL ELECTRIC HYBRIDS	EN 1821-2	NWIP	
3 FUEL CELL HYBRID VEHICLES	pr EN 1821-3 (NWIP)		
4 PURE FUEL CELL VEHICLES	pr EN 1821-4 (NWIP)		
ENERGY PERFORMANCE			
1 PURE ELECTRIC VEHICLES	EN 1986 -1	8714	R.101
2 THERMAL ELECTRIC HYBRIDS	EN 1986 -2	NWIP BASED ON CEN, JEVA, SAE	R.101 (Proposed Amendment)
3 FUEL CELL HYBRID VEHICLES	pr EN 1986-3 (NWIP)		
4 PURE FUEL CELL VEHICLES	pr EN 1986-4 (NWIP)		
EMISSIONS			
1 THERMAL ELECTRIC HYBRIDS	EN 13444-1	NWIP BASED ON CEN, JEVA, SAE	R.83 (Proposed Amendment)
2 FUEL CELL HYBRID VEHICLES	pr EN 13444-2 (NWIP)		
3 PURE FUEL CELL VEHICLES	pr EN 13444-3 (NWIP)		

= Approved / Published

NWIP = New Work Item Proposal

Standards for Electrically Propelled Road Vehicles
Safety Requirements

ITEM	STANDARDIZATION BODY		INTERNATIONAL LEGAL REQUIREMENTS
	CEN	ISO	ECE / ONU
REQUIREMENTS FOR ELECTRIC / HYBRID VEHICLES			
Part 1 ON BOARD ENERGY STORAGE	EN 1987-1	6469-1	R.100
Part 2 FUNCTIONAL SAFETY MEANS AND PROTECTION AGAINS FAILURES	EN 1987-2	6469-2	R.100
Part 3 PROTECTION OF USERS AGAINST ELECTRICAL HAZARDS	EN 1987-3	6469-3	R.100
GASEOUS EMISSIONS PRODUCED BY BATTERIES	WG4-13	SC21-270 (NWIP) BASED ON SAE J1718	R.100 (Proposed Amendment)
FUEL CELL POWERED ROAD VEHICLES		Europe / Japan / USA	
Part 1 SAFETY MEANS AGAINST HYDROGEN HAZARDS		WG1 – Europe 71 – Japan 80 – USA 83, 84	
Part 2 FUNCTIONAL SAFETY MEANS		WG1 – Europe 72 – Japan 78 – USA 83, 84	
Part 3 PROTECTION OF USERS AGAINST ELECTRICAL HAZARDS		WG1 – Europe 73 – Japan 79 – USA 83, 84	
Part 4 ON BOARD ELECTROCHEMICAL ENERGY STORAGE FOR THE PROPULSION SYSTEMS		WG1 – Europe 74 – USA 83, 84	
FUEL CELL SYSTEM		WG1 – Japan 77 – USA 83, 84	
BASIC CONSIDERATIONS FOR THE SAFETY OF HYDROGEN SYSTEMS		TC197N166-DPASS15916	

(green) = Approved / Published

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Parameters for fuel storage systems

- Weight
- Volume
- Costs
  - Purchasing
  - Operative
- Refuelling time
- Life

Options for hydrogen storage system

NOWADAYS

Degree of complexity

Compressed (pressure range : 200 bar up to 700 bar)

Liquid (criogenic at both ambient pressure and pressurized)

Metal Hydride (High or Low Temperature)

THE FUTURE ?

Study phase

Nanostructures (carbon nanotubes, …)

Comparison of hydrogen storage systems

COMPRESSED HYDROGEN

In favor :

- storage systems are well known and in development
- some vehicles already have infrastructure for gaseous fuels
- low weight of next generation systems

Adverse :

- low energy density (kg/l)
- energetic costs associated to high pressure vessels (> 500 bar)
- safety aspects of the transportation of a pressurized fuel

LIQUID HYDROGEN

In favor:

- energy density is about 3.5 energy density of compressed hydrogen at 300 bar

Adverse :

- energetic costs for liquefaction
- amount of gas released due to daily evaporation rate for small tank
- temperature stratification
- careful in maintenance operations

METAL HYDRIDE

In favor:

- energy density higher than compressed hydrogen storage system
- hydrogen release with cathode exhaust stream (LT MH)
- low pressure system

Adverse :

- hydrogen mass content in LTMH
- dynamic response of the system
- fatigue operation resistance
- number of required auxiliaries

Hydrogen Storage System Alternatives

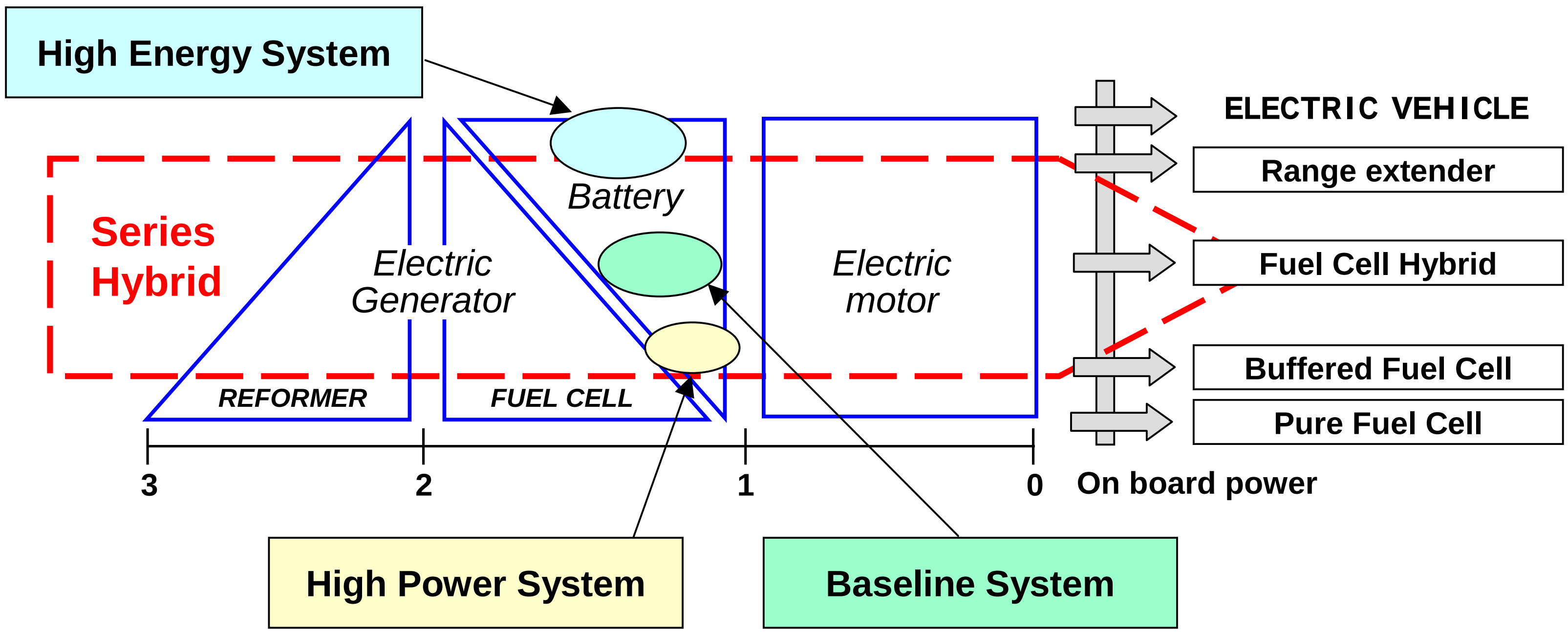
- **Solution to be investigated**
  - Metal hydrides adsorption
  - Nanotubes / microfibers adsorption
  - High pressure compressed
  - Liquefied

- **Aspects to be analyzed**
  - Safety
  - Infrastructure / refilling interface
  - Technology study
  - Economical
  - Well to wheel (well to storage output) efficiency

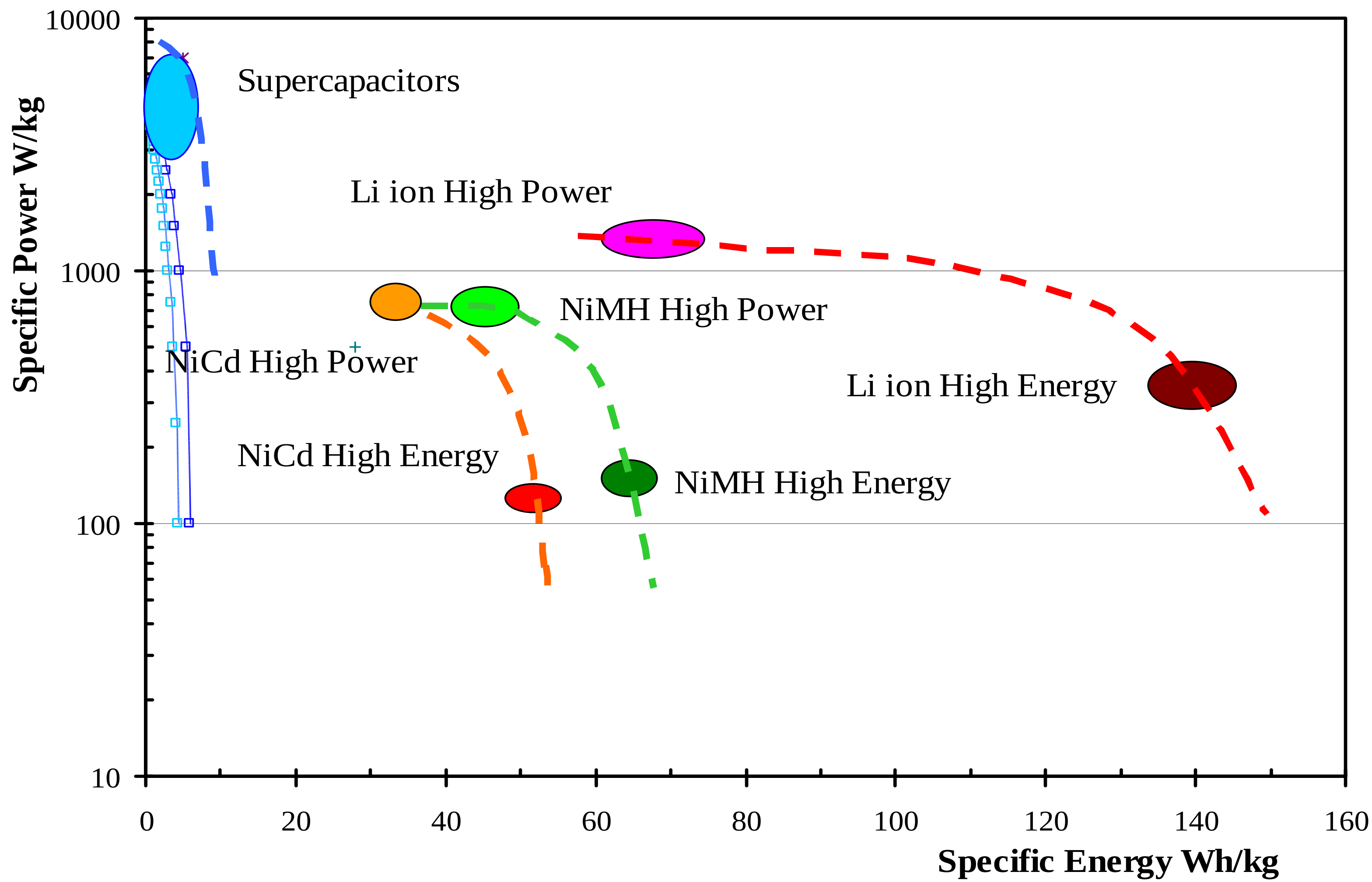
System Architecture for
Fuel Cell and Battery Vehicle

Systems Architecture	Fuel Cell Sizing	Use	Storage unit features and management
Pure electric, battery povered	==	Urban	High energy Recharge from mains
Battery, powered with fuel cell APU	Reduced (average power of urban and extraurban cycle)	Urban and extraurban with range extender	High energy Recharge from mains
Hybrid with buffer	Sized to meet continuous Vmax	General purpose suburban	Peak Power (battery or supercapacitor)
Pure Fuel Cell	Sized for the maximum power requested	General purpose extraurban	= =

System Architectures for Fuel Cell Vehicles



Comparison Power vs. Energy Storage



Cluster Land Transport by Fuel Cell Technology

Cluster Administrator: ika

FUERO ERK6-CT1999-00024
Fuel Cell Systems and Components General Research for Vehicle Applications

- Study on Fuel alternatives - Life cycle analys.
- Systems specification
- System integration studies
- Modelling Interface for components
- Components specifications
- Test procedures definition
- State of the art assessment – Benchmarking new component testing and evaluation
- Life cycle assessment (Modelling)
- Demontrators definition
- Fuel cell general assessment
- Cluster coordination

Partners: ika, CRF, PSA, RENAULT, VOLVO, VW, IFP
Coordinator: ika
Steering committee: Car manufacturers

Experimental Performance and Life Cycle Assessment of FC Vehicles

Demo	Demo	...	Demo
Partners: Car Makers Comp.Manuf Research Inst. Coordinator: Car Maker	Partners: Car Makers Comp.Manuf. Research Inst. Coordinator: Car Maker		Partners: Car Makers Comp.Manuf. Research Inst. Coordinator: Car Maker

PROFUEL ERK6-CT1999-00023
On-Board Gasoline Processor for Fuel Cell Vehicle Application
Partners: Johnson Matthey, CRF, ECN, FEV, ANSALDO, Politecnico di Torino, Volvo
Coordinator: Johnson Matthey

BIO-H2 ERK6-CT1999-00012
Production of clean Hydrogen for Fuel Cell by Reformation of Bioethanol
Partners: CRF, ENEA, PCA, REN, IRC, URE, UPAT, ECN
Coordinator: CRF

ASTOR NNE5-1999-20138
Assessment & Testing of Advanced Energy Storage System for Hybrid Electric Vehicle
Partners: VW, BMW, CRF, DaimlerChrysler, OPEL, PSA, Renault, Volvo
Coordinator: VW

PEM-ED ERK6-CT1999-00025
Proton exchange membranes for application in medium temperature electrochemical devices
Partners: FuMA-Tech, Nuvera ...
Coordinator: FuMA-Tech

AMFC
Advanced Methanol Fuel Cell
Partners: AB Volvo,Tech. University of Denmark, University of Newcastle, Norwegian University of Science and Tech., Proton Motor FC, den norsk stats oljeselskap,
Coordinator: AB Volvo

DREAMCAR
Direct Methanol Fuel Cell Development for Hybrid Car
Partners: SODETEG, CRF, CRN-ITAE, Solvay, Ramot
Coordinator: SODETEG

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