

3 Preface

Knowledge

→ Fundamentals

- 8 The origin of hydrogen
Martin Völkening, TÜV Süddeutschland Bau und Betrieb GmbH /
Andreas Ringwald, DESY Deutsches Elektronen-Synchrotron
- 9 The energy carrier hydrogen
Judith Ortenburger, TÜV Süddeutschland Bau und Betrieb GmbH
- 10 The road to hydrogen – a historical retrospect
Wolfgang Burmeister, ARGEMUC
- 11 The fuel cell – electricity and heat from hydrogen
Stefan Nettesheim, Staxon GmbH / Holger Klos, P21 GmbH
- 12 The membrane electrode assembly – heart of the PEM fuel cell
Carsten Henschel, Celanese AG
- 14 Energy conversion and efficiency
Boris Chen / Ulrich Wagner

Technology I

→ Approaches to hydrogen production

- 18 Hydrogen generation by electrolysis
Rolf A. Brand, GHW Gesellschaft für Hochleistungselektrolyseure
zur Wasserstoffzeugung mbH
- 20 Hydrogen from fossil energy sources
Joachim Wolf, Linde AG
- 22 Hydrogen production with heavy hydrocarbons
Ulrich Wagner
- 22 What part do catalysts play?
Norbert Modl, Süd-Chemie AG
- 23 Hydrogen from biomass
Heinz-Jürgen Mühlen

- 24 Hydropower for hydrogen generation
Serge Roy, Hydro-Québec
- 26 Solar hydrogen generation
Ulf Groos, Fraunhofer-Institut für Solare Energiesysteme ISE
- 28 Hydrogen generation from wind energy
Wolfgang Schönharting, Solantis Energy AG / Stefan Nettesheim, Staxon GmbH

→ Variety of storage solutions

- 30 Liquefaction and storage of hydrogen
Joachim Wolf, Linde AG
- 32 Hydrogen compressed gas storage
Christian Rasche, Dynetek Europe GmbH /
Martin Kesten, Dynetek Europe GmbH
- 35 Hydrogen storage in hydrides
Marc Hubert, HERA Hydrogen Storage Systems Inc. /
Andreas Otto, HERA Hydrogen Storage Systems GmbH
- 36 Research field hydrogen storage
Walter Schütz, FutureCamp GmbH

Technology II

→ Industrial use

- 40 H₂ use: foodstuffs, semi-conductors and bacteria
Joachim Wolf, Linde AG

→ Use in space travel

- 42 Fuel requirements in space travel
Bianca Zotz, Astrium GmbH

→ Hydrogen-based mobility

- 44 Innovation and increase in efficiency – evolution of vehicle concepts
Ingrid Paulus, Audi AG
- 46 Internal combustion engine with hydrogen technology
Andreas Klugescheid, BMW Group
- 50 Mobile with hydrogen and fuel cells
Hans-Peter Schmid, DaimlerChrysler AG

- 54 Hydrogen-powered buses as pioneers
of future transport
Christian Gruber, MAN Nutzfahrzeuge AG
- 56 Environmentally friendly technology – undreamed of design freedom
Erhard Schubert, Adam Opel AG
- 60 Fuel-cell hybrid vehicles –
Toyota's strategy of diversity
Kazuhiko Takahashi, Toyota Motor Corporation
- 64 Fuel-cell buses – the future for local public transport?
Felix Heidelberg, PROTON MOTOR GmbH
- 65 High efficiency – fuel-cell drive systems for vehicles
Jochen Straub, Ballard Power Systems AG
- 66 Submarines with fuel-cell propulsion as a standard system
Jürgen Rohweder, Howaldtswerke-Deutsche Werft AG

→ Portable systems

- 68 Miniature fuel-cell systems – a substitute for batteries?
Christopher Hebling, Fraunhofer-Institut für Solare Energiesysteme ISE /
Ulf Groos, Fraunhofer-Institut für Solare Energiesysteme ISE
- 70 Fuel cells in small applications
Klaus Bonhoff, Ballard Power Systems AG
- 71 Energy for mains-independent systems
Manfred Stefener, SFC Smart Fuel Cell AG

→ Stationary applications

- 72 Hospital routine with a fuel-cell power plant
Jörg Demmler, Rhön-Klinikum AG
- 74 The virtual power plant – united on a decentralized basis
Kai Klinder, Vaillant GmbH
- 75 The virtual power plant – a comparison
Ulli Arndt, Forschungsstelle für Energiewirtschaft e. V. /
Dieter Köhler, enwikon Energiewirtschaftliche Konzepte GmbH

→ Stationary applications and prospects

- 76 Hydrogen in the energy industry –
prospects for an energy supplier
Hans Rainer, E.ON Energie AG

Prospects

→ Scenarios

- 80 Energy scenarios to 2050
Klaus Picard, Deutsche Shell

→ Infrastructures

- 84 Hydrogen infrastructures
Boris Chen / Peter Diekmann
- 88 The Munich H₂ filling station:
cooperation model and pioneering achievement
Wolfgang Burmeister, ARGEMUC

→ Strategies

- 90 Success of a long-term strategy –
the Bavarian Hydrogen Initiative
Ulrich Wagner, Coordination Center of the Bavarian Hydrogen Initiative
- 92 New technologies, economic potential and environmental issues –
from a Canadian perspective
Randall Mang, Natural Resources Canada /
National Research Council Canada
- 95 Emissions trading
Roland Geres, FutureCamp GmbH / Michael Schmalholz, FutureCamp GmbH

→ Process chains

- 96 Life-cycle assessment of hydrogen energy systems
Ulrich Wagner

→ Safety and reliability

- 100 Safety in handling hydrogen
Judith Ortenburger, TÜV Süddeutschland Bau und Betrieb GmbH
- 102 Test beds for hydrogen-powered engines
Raimund Zilmans, TÜV Automotive GmbH

103 Concluding remarks

104 Glossary