## Contents

Нус	drogen as an Energy Carrier – A Guide (CJ. Winter)	1
Par	et A: Significance and Use of Hydrogen	11
1.	Energy Supply Structures and the Importance of Gaseous Energy Carriers (J. Nitsch)	13 13 16 19 22 27
2.	Technologies for the Energetic Use of Hydrogen (W. Peschka)	30 30 40 42 48
3.	Hydrogen as Raw Material (W. Schnurnberger)  3.1 Present Situation and Future Development.  3.2 Non-energetic Use in the Chemical Industry.  3.3 Indirect-energetic Use of Hydrogen.  3.4 Non-fossil Hydrogen as a Raw Material.	56 56 59 65 75
4.	Safety Aspects of Hydrogen Energy (M. Fischer, H. Eichert) 4.1 Introduction	79 79 80 87 90
Par	rt B: Production of Hydrogen from Nonfossil	

Primary Energy.....

93

<b>5.</b>	Photovoltaic Electricity Generation (G.H. Bauer)	95
	5.1 Physical Mechanism	95
	5.2 Technology of Solar Cell Production	111
	5.3 Solar Cell Moduls and Generators	128
	5.4 Present Status of Photovoltaic Technology	131
	5.5 Goals and Future Developments	133
6.	Thermo-mechanical Electricity Generation (J. Nitsch)	140
_	6.1 Thermodynamics of Solarthermal Energy Conversion	140
	6.2 Production of High Temperature Heat by Means of Solar	
	Energy	144
	6.3 Production of Heat by Means of Nuclear Energy	149
	6.4 Thermodynamic Cycles for Electricity Generation	151
	6.5 Mechanical Energy Conversion for Electricity Generation	156
	6.6 Indirect Possibilities of Solar Energy Utilization	161
	6.7 Possibilities for Hydrogen Production	164
	U. I describing to Hydrogen I roduction	10.
7.	Water Splitting Methods (H. Wendt)	166
	7.1 Survey	166
	7.2 Thermodynamics of Water Splitting	168
	7.3 Energy Balance of Chemo-technical Processes	170
	7.4 Conventional Processes of Water Splitting with Hydrocarbons	
	or Coal as Primary Energy Source	173
	7.5 Water Splitting by Electrolysis	177
	7.6 Water Splitting by Thermochemical Cycles	190
	7.7 Economic Comparison of Different Water Splitting Methods	197
	7.8 Further Methods of Water Splitting	200
	7.0 I difficilizations of water Spiromag	200
8.	Selected Hydrogen Production Systems	
	(W. Schnurnberger, W.Seeger, H. Steeb)	209
	8.1 Survey and Selection of Systems	209
	8.2 Technology and Electrolyser Plants	212
	8.3 Electrolysis and Hydropower	218
	8.4 Electrolysis and Nuclear Power	219
	8.5 Electrolysis and Solar Thermal Power	221
	8.6 Electrolysis and Wind Power	226
	8.7 Electrolysis and Photovoltaic Power	231
	•	
9.	Storage, Transport and Distribution of Hydrogen	
	(C. Carpetis)	249
	9.1 Introduction	249
	9.2 Storage Types and Storage Methods	250
	9.3 Large Hydrogen Storage	265
	9.4 Long-distance Hydrogen Transport	269
	9.5 Short-distance Transport and Distribution	280
	9.6 End-user Hydrogen Storage	283

Par	rt C: Design of a Future Hydrogen Energy Economy	29
10.	Potential and Chances of Hydrogen (J. Nitsch, C. Voigt)  10.1 Future Contribution of Hydrogen	29 29
	Energy Sources	30
11.	Hydrogen in a Future Energy Economy (J. Nitsch, C. Voigt) 11.1 Hydrogen Production with Large Solar- and Wind-Stations. 11.2 Development Strategy and Expenditures for the Production	31 31
	of Large Amounts of Hydrogen	33
	11.3 Long-distance Transport Systems	33
	Hydrogen	34
	Share	34
12.	Concepts for the Introduction of Nonfossil Hydrogen	
	(J. Nitsch, C. Voigt)	358
	12.1 Introduction into Industrialized Countries	358
	12.2 Decentralized Use of Hydrogen in Southern Countries	36
13.	Energy-economic Conditions and the Cooperation with	
	Hydrogen Producing Countries (J. Nitsch, H. Klaiß)	368
	13.1 Capital Requirements	368
	13.2 Funding Possibilities	370
	13.3 Cooperation with Hydrogen Producing Countries	371
	13.4 Steps to Solar Hydrogen	372
Inde	ex	37
TITUE	·A · · · · · · · · · · · · · · · · · ·	011