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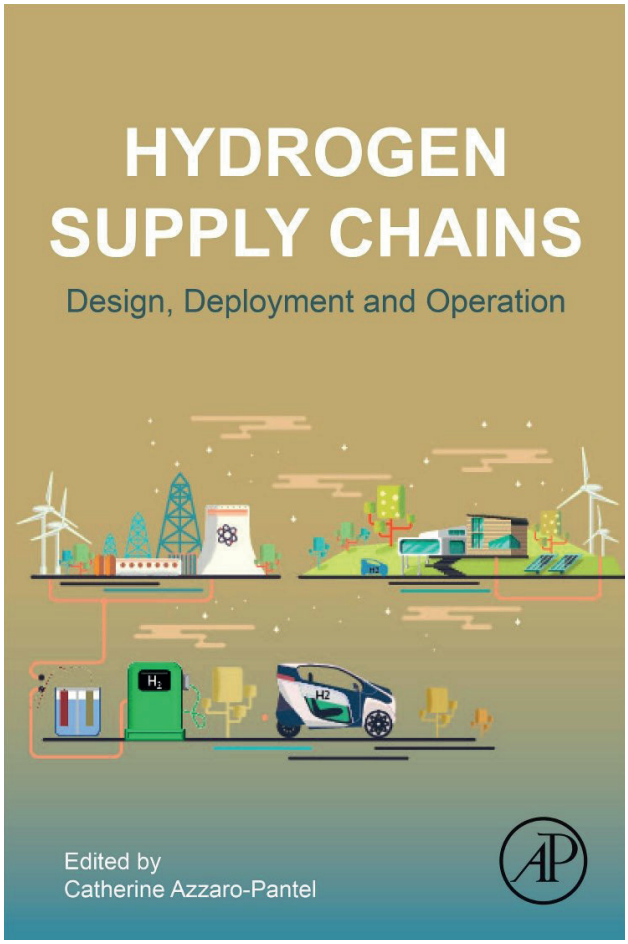
BOOKS REVIEW



HYDROGEN SUPPLY CHAINS - DESIGN, DEPLOYMENT AND OPERATION

Edited by Catherine Azzaro-Pantel

The pathway to develop a hydrogen economy is very flexible due to the variety of available energy sources, production processes, and transportation and storage modes. Considering this scenario, Hydrogen Supply Chains: Design, Deployment and Operation demonstrates how each part of a hydrogen supply chain (HSC) is interconnected. It explores these parts from different angles to form a well-rounded view of the entire chain, including techno-economic and environmental aspects.

This book introduces the current energy system and the challenges that may hinder the large-scale adoption of hydrogen as an energy carrier. It then moves on to cover the different aspects of a methodological framework for designing a HSC, including production, storage, transportation, and infrastructure. The advantages and drawbacks of each technology are evaluated, including their technology readiness level (TRL). The multiple applications of hydrogen for energy are presented, including its use in fuel cells, combustion engines, as an alternative to natural gas and power to gas. Through analysis and forecasting of hydrogen markets, the authors explore deployment scenanos, considering the dynamic aspect of HSCs and its intrinsic uncertainty in matching supply and demand. They also propose methods and tools that can be selected for a multi-criteria optimal design, including performance drivers and economic, environmental, and societal metrics.

The introductory chapter is devoted to the exploration of the major roles that hydrogen is likely to play in the economy, with a specific focus on decarbonization. The concept of Power-to-Gas used in HSC is presented. The objective of this chapter is to present the concept of the HSC and its main activities, including multiple sources/multiple uses, production, storage, transportation and distribution, multiples stakeholders, multiperiod strategies in a context of uncertainty (for instance demand). The criteria to be taken into account in a sustainable development context are also highlighted. The pillars of the HSC - production, storage, and distribution are explored in the three following chapters, which will present hydrogen production processes at various scales from macroscopic to process scale, as well as state-of-the art reviews.

The optimization of cost and energy consumption for compression, transportation, and storage of hydrogen for vehicle refueling in the current hydrogen emerging market is addressed in chapter 6 by considering a recurrent issue in HSC development, that is, the location of a refueling station on a hydrogen production site and the case of a production unit supplying hydrogen to several distant refueling stations.

Chapter 7 explores the large range of potential applications of hydrogen from industry to the transport sector, currently and in the longer term. For each of these applications, the potential for economic competitiveness is discussed by highlighting the main drivers and variables.

Social aspects of HSC are discussed in chapter 8. The deployment of a hydrogen economy is not without trials and controversies, doubts and value oppositions. Using hydrogen as energy storage for renewables is particularly sound in an island context. The Corsican PV-Hydrogen MYRTE Platform serves here as a test bench for investigating the close links between technical aspects and political obligations, and the role of stakeholders.

Chapter 9 provides the reader with Power-to-Gas (PtG) Concepts, demonstration and prospects. In this vision,

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Detritus / Volume 05 - 2019 / pages X-XI
https://doi.org/10.31025/2611-4135/2019.13794

hydrogen from electrical energy via electrolysis is viewed as the first possible end-product of the so-called Power-to-Gas process chain or can be further converted to synthetic methane via methanation, a process requiring the feed-in of CO_2. The potentials, opportunities, and limitations of PtG are presented in this chapter.

Chapter 10 deals with methods and tools for optimizing HSC design. The most current trend is based on multiobjective formulations. Decision-aid methods to search for tradeoff solutions are often used; the benefits provided by the use of geographic information systems are examined. The focus of chapter 11 is on multiobjective life cycle optimization of HSC, proposing the formulation of the design of hydrogen networks as a mixed-integer linear programming problem including environmental objectives along with economic ones.

In chapter 12, a robust engineering strategy that has been applied to hydrogn pipleline networks of a large-scale refinery has been developed for optimal scheduling of the hydrogen system to reduce energy cost and carbon emissions in refineries. In chapter 13, optimal design of refinery hydrogen system with purification unit is discussed by introducing both the pinch technique and mathematical programming approches.

Chapter 14 shows how the programmable structure of process models can be generated from the description of a process network (optionally geographically determined and multiscale) and from two general functional metaprototypes.

Chapter 15 deals with a case study of using life cycle assessment of hydrogen supply chain for Japanese automotive use to understand the role of hydrogen in reducing greenhouse gas emissions in the vehicle transport sector from a life cycle perspective.

The last chapter focuses on methods to assess safety risks in the future hydrogen-based infrastructure. The development of new large-scale infrastructure is viewd as gradual procedure requiring different decision support tools, including cost-benefit assessments, sustainability assessments, optimization of supply chains, the best placement of buildings and process equipment in a growing market, and, last but not least, safety risk assessment and management.

Overall, due to its systems-based approach, this book is ideal for engineering professionals, researchers, and graduate students in the field of energy systems, energy supply and management, and process systems. As it also provides a thorough overview of the hydrogen supply chain, it is a useful resource for energy analysts, consultants, and policy makers.

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Catherine Azzaro-Pantel, received her PhD in Chemical Engineering from the Institute National Polytechnique (INP), Toulouse, France. She is a Professor of Process Systems Engineering at the Ecole Nationale Supérieure des Ingénieurs en Arts Chimiques et Technologiques (INP-ENSIACET), University of Toulouse, France, where she co-founded a master-level program in EcoEnergy. This program's goal is to provide engineers with a state-of-the-art education in the area of advanced energy technologies and systems. Her research interests lie in the area of process systems engineering with specific focus on optimization methods for process design (deterministic and stochastic methods). Hydrogen supply chains have been the core of several of her research works for many years. She is the author or co-author of over a hundred scientific publications, including articles, conference proceedings, a book and several book chapters.

Book Info:

Editor: Catherine Azzaro-Pantel
Imprint: Academic Press
Year of publication: 2018
Page Count: 588
Paperback ISBN: 9780128111970