

Preface

Structure of this book and how to read it

This book is divided into three parts:

- Part I Fundamentals,
- Part II Validation of nominations,
- Part III Verification of booked capacities.

Part I gives fundamental information about the planning problems arising in gas transport and is structured as follows: Chapter 1 gives an introduction to the main topics of this book and describes the overall setting. Chapter 2 will define the notation and technical basics of *gas networks* as used throughout the book. Chapter 3 explains why we have to deal with the evaluation of gas network capacities in the first place (other than for technical reasons) by giving all the legal background needed. (Appendix A provides further details.) Chapter 4 describes the state of the art of gas transport planning using simulation.

Part II deals with approaches for the validation of nominations problem. In Chapter 5 we move from simulation to optimization in order to deal with the validation of nominations (NoVa) problem. Chapters 6–9 describe different approaches for obtaining discrete decisions, which are validated by a high precision nonlinear program (NLP), presented in Chapter 10. Chapter 11 reviews the methodology and puts it into perspective, discussing the interpretation of the results. Chapter 12 gives computational results using all the methods described in Chapters 6–10.

Part III discusses approaches for the verification of bookings. Chapters 13 and 14 deal with the generation of realistic nominations, taking into account past, future, and legal aspects; this will lead to an approach to deal with the verification of bookings. We will also present some computational results for the verification of bookings. Finally, Chapter 15 will provide an outlook on what further, more involved questions might be answered by building upon the results presented in this book.

As a rule of thumb, the following combinations of chapters can be read independently:

- ▷ Chapter 2 gives an independent introduction to gas transport modeling.
- ▷ Chapters 3 and 4 give an introduction into the current legal conditions and state of the art. Appendix A provides further background into the legal setup.
- ▷ Chapter 5 provides the basic setting for Chapters 6–10. Each of the five latter chapters is independent from the others.
- ▷ Chapter 11 requires some knowledge about Chapters 5 and 6–10; in particular requires Chapters 6 and 10.
- ▷ The computations presented in Chapter 12 require knowledge about the individual approaches, i.e., Chapters 6–10.

- ▷ Chapters 13 and 14 describe the approach for the verification of bookings and present some computational results.

Let us finally list some additional information on the structure of this book:

- ▷ A glossary for terminology of gas transport starts on page 331.
- ▷ An index is given starting on page 361.
- ▷ There are two tables inside the front and back covers of this book, respectively, that contain a list of physical and technical quantities and constants that are used throughout this book.
- ▷ Moreover, this book contains two lists of literature. The first starting on page 339 contains references for legal or gas business related information; the corresponding citations are marked in brackets, e.g., [GasNZV 2005]. The second starting on page 345 contains mathematical literature; its citations use parentheses, e.g., Domschke et al. (2011).

Goals of this book

The main goal of this book is to provide an introduction to the field of gas transport planning. We highlight the many interesting mathematical questions that arise in this context. Moreover, we describe the above mentioned new approach for evaluating the capacity of a gas network in detail.

In particular, this book provides the following information:

- ▷ Chapter 2 provides a compact description of the main mathematical concepts and formulas needed to describe gas transport.
- ▷ We describe the legal framework for gas transport (Chapter 3) and the state of the art (Chapter 4).
- ▷ Four approaches to find (discrete) decisions for the active elements in order to transport a given load situation are developed (Chapters 6–10). The outcome of these methods is used in order to find a solution of a more accurate NLP model (Chapter 10).
- ▷ Chapters 13 and 14 provide an approach to automatically generate stressing load situations.
- ▷ Finally, we present computational results of the proposed methods in Chapters 12 and 14.

We thus see this book just as a first step towards the development of mathematical concepts and results that arise in this area with the goal of providing practically useful methods.

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Untersuchung der technischen Kapazität von Gasnetzen
(Investigation of the technical capacity of gas networks)

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The goal of the project was to improve the mathematical methods used for mid- to long-term capacity planning of gas transportation networks. It was conducted between 2009 and 2012 and has been triggered by another project, called *Forschungskooperation Netzoptimierung* (ForNe) (Research cooperation network optimization) that was initiated

by Germany's largest gas transport system operator Open Grid Europe GmbH (OGE) due to the challenges imposed by new regulations on gas transportation. ForNe has been executed by OGE and Friedrich-Alexander-Universität Erlangen-Nürnberg, Humboldt-Universität zu Berlin, Technische Universität Darmstadt, Leibniz Universität Hannover, Universität Duisburg-Essen, Weierstraß Institut für Angewandte Analysis und Stochastik (WIAS), and Zuse Institute Berlin (ZIB). In particular, the authors of this book were involved. As of this writing ForNe is still running, working on bringing the results obtained into daily practice.

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