Preface

This book describes a tool for mathematical modeling: the Python Optimization Modeling Objects (Pyomo) software. Pyomo supports the formulation and analysis of mathematical models for complex optimization applications. This capability is commonly associated with algebraic modeling languages (AMLs), which support the description and analysis of mathematical models with a high-level language. Although most AMLs are implemented in custom modeling languages, Pyomo's modeling objects are embedded within Python, a full-featured high-level programming language that contains a rich set of supporting libraries.

Modeling is a fundamental process in many aspects of scientific research, engineering and business, and the widespread availability of computing has made the numerical analysis of mathematical models a commonplace activity. Furthermore, AMLs have emerged as a key capability for robustly formulating large models for complex, real-world applications [53]. AMLs streamline the process of formulating models by simplifying the management of sparse data and supporting the natural expression of model components. Additionally, AMLs like Pyomo support scripting with model objects, which facilitates the custom analysis of complex problems.

The core of Pyomo is an object-oriented capability for representing optimization models. Pyomo also contains packages that define modeling extensions and model reformulations. For example, the `pyomo.pysp` package defines modeling extensions for stochastic programs as well as solvers that can analyze these problems. Pyomo also includes packages that define interfaces to solvers like CPLEX and Gurobi, as well as solver services like NEOS.

Goals of the Book

This second edition provides an updated description of Pyomo's modeling capabilities. A key goal of this book is to provide a broad description of Pyomo that will enable the user to develop and optimize models with Pyomo. The book uses many examples to illustrate different techniques that can be used to formulate models.

Another goal of this book is to illustrate the breadth of Pyomo's capabilities. Pyomo supports the formulation and analysis of common optimization models, including linear programs, mixed-integer linear programs, nonlinear programs, mixed-integer nonlinear programs, mathematical programs with equilibrium constraints, generalized disjunctive programs, bilevel programs, and stochastic programs. Additionally, Pyomo includes solver interfaces for a variety of widely used optimization software packages, including CBC, CPLEX, GLPK, and Gurobi. Additionally, Pyomo models can be optimized with optimizers like IPOPT that employ the AMPL Solver Library interface.

Finally, a goal of this book is to help users get started with Pyomo even if they have little knowledge of Python. Appendix A provides a quick introduction to Python, but we have been impressed with how well Python reference texts support new Pyomo users. Although Pyomo introduces Python objects and a process for applying them, the expression of models with Pyomo strongly reflects Python's clean, concise syntax.

However, our discussion of Pyomo's advanced modeling capabilities assumes some background in object-oriented design and features of the Python programming language. For example, our discussion of modeling components distinguishes between class definitions and class instances. We have not attempted to describe these advanced features of Python in the book. Thus, a user should expect to develop some familiarity with Python in order to effectively understand and use advanced modeling features.

Who Should Read This Book

This book provides a reference for students, academic researchers and practitioners. The design of Pyomo is simple enough that it has been effectively used in the classroom with undergraduate and graduate students. However, we assume that the reader is generally familiar with optimization and mathematical modeling. Although this book does not contain a glossary, we recommend the Mathematical Programming Glossary [45] as a reference for the reader.

Pyomo is also a valuable tool for academic researchers and practitioners. A key focus of Pyomo development has been on the ability to support the formulation and analysis of real-world applications. Consequently, issues like run-time performance and robust solver interfaces are a priority.

Additionally, we believe that researchers will find that Pyomo provides an effective framework for developing high-level optimization and analysis tools. For example, Pyomo provides generic solvers for stochastic programming, and it leverages the fact that Pyomo's modeling objects are embedded within a full-featured high-level programming language. This allows for transparent parallelization of sub-problems using Python parallel communication libraries. This ability to support generic solvers for complex models is very powerful, and we believe that it can be used with many other optimization analysis techniques.

Revisions for the Second Edition

We have made several major changes while preparing the second edition of this book. The book was divided into two parts: (1) chapters that provide an introduction to optimization and Pyomo, and (2) chapters that describe advanced features and extensions. The introductory chapters were revised to provide a more tutorial description. In particular, reference material was removed from the first edition, which will be provided online at the Pyomo website. The chapters describing advanced features were extended to include new functionality added to Pyomo since the first edition, including generalized disjunctive programming, mathematical programming with equilibrium constraints, and bilevel programming.

Comments and Questions

This book documents the capabilities of the Pyomo 5.1 release. Most examples in the book work with Pyomo 5.0, but some errors in Pyomo DAT file processing were resolved in the Pyomo 5.1 release. Further information is available on the Pyomo website:

```
http://www.pyomo.org
```

Pyomo's open source software is hosted at GitHub:

```
https://github.com/Pyomo/pyomo
```

We encourage feedback from readers, either through direct communication with the authors or with the Pyomo Forum:

```
pyomo-forum@googlegroups.com
```

We hope this will include feedback on the presentation of this material, including typos and errors in our examples. Note that all of the examples used in this book are included with Pyomo in the pyomo/examples/doc/pyomobook directory!

Good Luck!

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