

Preface

Power systems regulation is never at rest. I have been working on regulation of the power sector in more than 30 countries and teaching this topic for about 25 years. Every year, when I set out to prepare the classes in my regulation courses and I examine the previous year's slides, I have to discard a fair amount and create fresh ones. New laws and norms have been approved, new successes and failures have been revealed, new regulatory instruments have been proposed and implemented, ideas that looked promising last year are already out-of-fashion today and others that were discarded in the past seem attractive now.

In regulation there are quieter periods and more active ones. Present times appear to demand a particularly active regulatory response. Energy—and electricity in particular—has recently become a fashionable topic. Energy news is now a staple in the media. Fifteen years ago nobody brought energy as a subject for discussion in a social get-together. In family gatherings my brother, a medical doctor, attracted quite some attention with questions about diverse health matters, while my energy activities were thoroughly ignored. Now I successfully compete with my brother.

There are very good reasons for energy—and electricity in particular—to have become a hot topic, and greater interest in energy and electricity regulation consequently followed. The power sector is at the core of the profound transformation that will be needed in the next few decades to decarbonise the world energy model, while supporting the electrification of transportation and heating and incorporating new features such as the strong penetration of renewable generation—distributed in a significant proportion—active demand participation facilitated by the widespread availability of communication and control technologies, massive efforts in energy conservation and efficiency, the creation of new services and business models at the retail level, the integration of local or national electricity markets into larger regional and transnational entities, and the implementation of effective approaches to achieve universal access to electricity.

The design and deployment of the multiplicity of answers to these difficult challenges in a diversity of contexts requires a thorough knowledge of power systems functions and technologies, mastery of the available modelling tools to represent power system behaviour and to support the decision making in all time

ranges—from protection of electromagnetic transients to long-term capacity expansion of the infrastructures of generation and networks—and the capability to assess any specific decision under engineering, economic, legal and even social or behavioural perspectives.

However, during the past two decades, most of the best universities in the world have disregarded research in power systems, thinking that it was a mature, already under control, well-known technology with little more to offer in terms of research... just to find out now that the power system, the “supreme engineering achievement of the twentieth century” according to the US National Academy of Engineering, has to undergo by the mid-twenty-first century the most drastic overhaul that any industry has ever experienced in such a short time: “to become almost fully decarbonized” if we are to maintain any hope of meeting the targets that climate scientists consider necessary to avoid catastrophic impacts of climate change. Not surprisingly, now we see numerous students in our universities interested in learning at the intersection of the engineering, economic, social and legal aspects of power systems because they want to make professional contributions in a variety of energy fields.

Power sector regulation already is and will increasingly be a key ingredient in any approach to the improvement and adaptation of worldwide energy models. As *The body of knowledge* of the Public Utility Research Center (PURC, <http://purc.org>) at the University of Florida rightly indicates: “There is a growing consensus that the successful development of utility infrastructure—electricity, natural gas, telecommunications and water—depends in no small part on the adoption of appropriate public policies and the effective implementation of these policies. Central to these policies is development of a regulatory apparatus that provides stability, protects consumers from the abuse of market power, guards consumers and operators against political opportunism, and provides incentives for service providers to operate efficiently and make the needed investments.”

A broad range of regulatory policies will be needed to unlock the considerable potential of the new technologies, institutional reforms and business models that are anticipated in the near future. These policies include establishing incentives for efficiency and innovation in operation and new investment of electrical facilities, adapting market rules to the advent of new technologies of production, making markets and governmental mandates compatible, removing non-economic barriers, promoting market competition and mitigating market power, developing public–private partnerships, encouraging new business and financial models and subsidising research and development.

I fell in love with power systems when I studied the subject at MIT in the late 1970s and early 1980s with giants like Fred Schweppe and Gerald Wilson. At that time Power Systems was an active area of research in US universities, with topics ranging from stability analysis of large interconnected systems, optimisation of centralised planning of capacity expansion and operation of generation and networks, improved design of electric machinery, development of advanced tariffs to stimulate efficient demand response or integrated resource planning. The traditional

gap between power systems technology, economics and regulation was getting narrower with innovative proposals on spot pricing of electricity, sophisticated mathematical models to support operational and strategic decisions and preliminary visions of restructuring and deregulation, as in the 1984 seminal book *Markets for Power* by Paul Joskow and Richard Schmalensee.¹

In 1984, equipped with this baggage and with a small group of bright and dedicated graduate students we commenced, at Comillas Pontifical University of Madrid, Spain, the adventure of creating from scratch a research institute, the Institute for Research in Technology (Instituto de Investigación Tecnológica, IIT, in Spanish) primarily devoted to conducting applied research for the electric power industry on a large variety of topics, mostly relying on detailed mathematical models as our method of analysis. Almost 30 years later, IIT, with more than one hundred researchers, is an international reference institution on power systems research and continues the tradition of blending technology, economics and regulation in a comprehensive approach to a large diversity of power system problems.

Accounting for regulation in the technical and economic analysis of power system problems has probably been the distinct trait of the research conducted at IIT during these almost 30 years. Most of the authors of this book have learned power sector regulation in practice, while consulting, teaching or participating in research projects for regulatory authorities, utilities and various institutions, initially in Latin American countries and later mostly in Europe and obviously also in Spain.

The research activities at IIT allowed me to build a body of knowledge that could be transferred to students in graduate courses. I started teaching a doctoral level course on power sector regulation at the Engineering School of Comillas University of Madrid in 1992, based on material from several intensive courses I had taught in Latin American countries during the previous years. In 2000, I was asked by the Council of European Energy Regulators (CEER) to organise a training course for the staff of European energy regulatory authorities. Under my direction, the first edition took place in 2002 as a very intensive 2-week course, where most of the instructors were experienced regulators. Around this course the Florence School of Regulation was created in 2004 within the Robert Schuman Center at the European University Institute in Florence, Italy. A few months earlier, IIT had accepted the proposal of the World Bank, via the Spanish CED-DET Foundation, of teaching an online course for the staff of governmental institutions and regulatory authorities in Latin America. This required the preparation of written tutorial material suitable for self-learning. This course was successfully run for 4 years. Taking advantage of this written material, conveniently translated into English, in the academic year 2005–2006 we turned the intensive short course of the Florence School of Regulation into an annual course that

¹ Meanwhile Chile had pioneered a revolutionary transformation of its power sector in 1981 (unknown at the time to most of the world), which contained most of the ingredients of the models of restructuring and liberalisation that swept the world one decade later.

combined presential and e-learning modules. This course has continued until the present time, under my direction.

Meanwhile, the initial course in regulation at Comillas University became the backbone of a 1-year Master's Program on the Electric Power Industry and later a 2-year Erasmus Mundus Master's Program, sponsored by the European Commission, with the participation of the Universities of Delft and Paris Sud XI. Under the leadership of the IIT-Comillas team, a new doctoral program was created in 2010, the Erasmus Mundus Joint Doctorate in Sustainable Energy Technologies and Strategies (SETS), jointly offered by Delft University, the Royal Institute of Technology (KTH) at Stockholm and Comillas University, in consortium with the John Hopkins University at Baltimore, USA, Paris Sud XI University and the Florence School of Regulation, again under the sponsorship of the European Commission. The course on power systems regulation is the glue that keeps the different subjects in the program together. Different versions of the regulation course, sometimes shorter, other times combined with other topics, have been employed by IIT researchers in diverse teaching activities for regulatory authorities or in collaboration with universities in Chile, Argentina, Colombia, Uruguay, Costa Rica, Italy, Turkey, Russia, Hungary or Lithuania as well as in Master's programs in the Dominican Republic and Peru.

In the academic year 2008–2009, I was invited by the Massachusetts Institute of Technology (MIT) to teach a course on “Engineering, economics and regulation of the electric power sector”. This was again an excellent opportunity to test and to improve the same teaching material with a quite different audience. The course has been very well accepted and it has become a permanent course during the Spring term at MIT.

Finally, we have decided to collect our experiences, writings and accumulated knowledge in this book. Contrary to what the term “edited-by” usually suggests—a more or less coherent collection of papers by different authors, which have been put together by an editor—this book is the “corpus” of knowledge distilled by the IIT team of researchers after about 25 years of teaching, research and consultancy in many countries.

This book is a collective work. It is centred around the regulation course that has been taught under multiple formats and in different contexts and that has been enriched by the experiences and the individual research paths of the co-authors of the different chapters. The e-learning material for CEDDET, which was later used at the Florence School of Regulation, has been the starting point. However, this book goes further into the complexities of regulation, and it cannot be considered an introductory text. In many respects it covers topics up to the current frontier of knowledge. This frontier changes quickly and I am sure that this book, if well-accepted, will have to be frequently updated.

The book adopts the point of view of the regulator. This is a logical consequence of having worked and taught frequently the course for the staff of regulatory commissions and public officials and, in the case of two of the authors, for having been commissioners in energy regulatory commissions. An interest in

electricity regulation may have multiple origins: government, staff of regulatory authorities, lobbyists, consumer associations, consultants or professionals of electricity utilities or energy service companies. Because of the institution they represent, sometimes these professionals defend regulatory positions that are not fully aligned with the common social interest. This is not the case of the independent regulator, whose goal must be to promote the public good. This undoubtedly encourages independent and creative thinking in search of what is best for society as a whole, and this is why we have adopted the independent regulator's perspective.

The book is directed at regulators, policy decision makers, business managers and researchers. It is a pragmatic text and we expect that power system professionals and students at all levels will benefit from the stock of blended theory and real-world-derived know-how that the book contains.

The IIT team of researchers has worked extensively in Spain, Latin America, the European Union and North America, but much less in the non-EU Europe, Africa, Asia and Oceania, where very interesting regulatory developments have also taken place. If the book is well-received, we shall try to correct this imbalance in future editions.

Arranged in four parts, the book addresses both traditional regulatory frameworks and also liberalised and re-regulated environments. First, an introduction gives a full characterisation of power supply including engineering, economic and regulatory viewpoints. Part II presents the fundamentals of regulation and the third part looks at the regulation of particular components of the power sector in detail. Advanced topics and subjects still open or subject to dispute form the content of Part IV.

It has been very encouraging how well-accepted the different courses on regulation that have led to this book have been. The book is dedicated to our students, who have overcome the difficulties of the frequently limited teaching material, have accompanied us in the learning of this complex subject and have inspired us with their sharp questions and their enthusiasm. We also thank the rest of our colleagues at IIT, both present and past, who are not explicit co-authors of the book but who have participated and contributed to its content in many ways. We express our gratitude to the numerous companies and institutions that have trusted us. The pioneer regulators of CEER, Jorge Vasconcelos, Jacques de Jong and Pippo Ranci, had the vision of asking for and supporting the training course for energy regulators that has become the flagship of the Florence School of Regulation. Miguel Angel Feito of CEDDET conceived the idea of our first e-learning course, where the very preliminary material for this book was prepared. The editorial staff of Springer have been always supportive of this project, and we thank them for their patience with our delays in delivering the manuscript and their careful editorial work. Tommy Leung from MIT and Paolo Mastropietro at IIT have carefully reviewed several chapters, pinpointing mistakes that otherwise

would had remained unnoticed to the authors. Margaret Clark has done a magnificent job of turning our texts of convoluted Spanish and, even worse, poor English, into elegant English prose. Some sections of the book have not benefited of her careful supervision, as the reader may easily discover.

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