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REVOLUÇÃO ENERGÉTICA: POLÍTICAS PARA UM FUTURO SUSTENTÁVEL

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3. Barreiras Econômicas e Sociais

HOWARD STEVEN GELLER

REVOLUÇÃO ENERGÉTICA: POLÍTICAS PARA UM FUTURO SUSTENTÁVEL

Tese de Doutorado Apresentada ao Programa Interunidades de Pós Graduação em Energia.
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Orientador:
Prof. Dr. José Goldemberg

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HOWARD STEVEN GELLER

Tese submetida ao Programa Interunidades de Pós-Graduação em Energia da Universidade de São Paulo, como parte dos requisitos necessários para obtenção do título de:

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Trabalho aprovado em ____/ ____/ _____

Prefácio

Comecei a escrever este livro em 1998 quando a energia ainda não era um tema tão importante. Os preços da energia estavam relativamente baixos e em queda. Os Estados Unidos e a maioria dos outros países industrializados estavam atravessando um forte crescimento econômico e os dirigentes estavam lutando com a crise econômica na Ásia. O aquecimento global, no entanto, estava atraindo atenção internacional. Com o aumento mundial das emissões de gases que causam aquecimento global, as nações se reuniram para limitar emissões futuras com a adoção do Protocolo de Kyoto. Porém, não ficou claro como os países industrializados poderiam atingir as metas do Protocolo de Kyoto e depois ir além.

Muito aconteceu para que as questões energéticas ganhassem destaque desde 1998. Os preços do petróleo subiram; o Brasil passou por uma séria crise de falta de energia; e o colapso da ENRON afetou os mercados financeiros e ameaçou com prejuízos políticos. Nos Estados Unidos, importantes iniciativas energéticas foram propostas pela Administração Bush e debatidas no Congresso dos EUA. Enquanto isso, ataques terroristas nos fizeram lembrar da vulnerabilidade de componentes chave de nossa infraestrutura energética.

Este livro vem num momento crítico. As evidências do aquecimento global continuam em curva de alta. Alguns países, regiões e empresas conseguiram um progresso considerável na redução das emissões dos gases que causam o aquecimento global. Em parte por causa dessa tendência, os mercados para tecnologias de energias mais limpas como turbinas eólicas, sistemas solares fotovoltaicos e lâmpadas fluorescentes compactas estão surgindo. Por outro lado, há forças poderosas que insistem em manter o padrão atual de produção e uso de energia - continuam a depender pesadamente de combustíveis fósseis incluindo o carvão e o petróleo, e consequentemente aumentam as emissões de gases de efeito estufa e intensificam o aquecimento global.

Vários outros livros e estudos sugerem que uma transição mundial dos combustíveis fósseis para fontes de energias renováveis, acompanhada de maior eficiência energética - uma revolução de energia limpa - é desejável e viável. Mas a maioria desses livros e estudos concentra-se nas tecnologias usadas para realizar essa transição, mas não aborda as estratégias para que essas tecnologias sejam implementadas. Acredito que o desafio principal não seja tecnológico. A maioria das tecnologias para uma revolução de energias limpas ou já está disponível comercialmente ou está emergindo no mercado. O desafio principal é como superar as barreiras que podem impedir a ampla adoção dessas tecnologias nas próximas décadas; isto é, como implementar uma revolução de energias limpas.

Escrevi este livro para ajudar a preencher essa lacuna. Houve várias experiências com políticas para melhorar a eficiência energética o suprimento de energias renováveis nos últimos dez ou vinte anos. Com base nessa experiência, agora é possível vislumbrar como se poderia realizar uma revolução energética durante este século. Este livro discorre sobre as políticas desenvolvidas até agora e analisa as lições obtidas com esforços passados para melhorar a eficiência energética e o uso de energias renováveis. Também recomenda e analisa políticas que poderiam ser adotadas para facilitar uma revolução de energias limpas no futuro.

Este livro procura ser holístico a partir de uma série de abordagens. Primeiramente, examina o grau de ameaças econômicas, sociais e ambientais apresentadas por um futuro que continue a produzir e a utilizar a energia nos padrões atuais e, da mesma forma, ver os benefícios oferecidos por uma revolução de energias limpas. O aquecimento global é considerado, como também a poluição atmosférica, riscos para a segurança, depleção de recursos locais e regionais e o saldo global. Em segundo lugar, cobre as experiências com políticas energéticas tanto em países industrializados quanto em desenvolvimento, além de experiências em nível local, estadual, nacional e internacional. Na verdade, optei por entrelaçar a cobertura geográfica na medida em que a liderança na implementação de maior eficiência energética e de fontes de energias renováveis e, por conseguinte, lições importantes foram proporcionadas igualmente por países ricos, de renda média ou carentes. Em terceiro lugar, discorre sobre políticas para melhorar a eficiência energética, fontes de energias renováveis e para ampliar o uso do gás natural por várias décadas. Todas essas estratégias são elementos importantes para uma potencial revolução de energias limpas.

Uma palavra sobre unidades de energia. Optei por utilizar unidades convencionais de energia de um país ou região em particular; por exemplo, quatriliões de Btus (quads) nos Estados Unidos, milhões de toneladas do equivalente em petróleo no Brasil, e milhões de toneladas do equivalente em carvão na China. Essas unidades são familiares para os leitores de cada região. O quadro ao final do prefácio apresenta os fatores de conversão de energia.

Tenho uma dívida de gratidão com muitas pessoas que me auxiliaram durante a jornada que culminou neste livro, que também foi minha tese de doutorado na Universidade de São Paulo. Primeiramente, gostaria de agradecer ao Professor José Goldemberg por se dispor a ser meu orientador e por me proporcionar apoio e estímulo. Em segundo lugar, gostaria de agradecer aos outros membros da banca, incluindo Gilberto Jannuzzi, José Roberto Moreira, Arthur Rosenfeld, e Roberto Schaeffer. Em terceiro lugar, gostaria de agradecer a David Zylbersztajn, que propôs que eu fizesse meu doutorado na USP, há cerca de dez anos, e me auxiliou a viabilizá-lo. Em quarto lugar, agradeço a Maria Cristina Vidal Borba e a Rafael Mantovani pela alta qualidade de sua tradução.

O livro parte de uma série de estudos que conduzi ou dos quais participei enquanto trabalhei como Diretor Executivo do American Council for an Energy-Efficient Economy (ACEEE) em Washington, DC. O Capítulo 5 utiliza colaborações anteriores com Steven Nadel, em particular, mas também com John DeCicco, Neal Elliott, Toru Kubo e Jennifer Thorne da ACEEE. Agradeço por suas inestimáveis contribuições.

A análise integrada de políticas no Capítulo 5 foi fornecida por Allison Bailie, Steve Bernow e Bill Dougherty do Tellus Institute em Boston, MA, sob minha direção. Agradeço imensamente por seu trabalho analítico minucioso e criteriosos deste estudo, bem como por outros esforços conjuntos ao longo dos anos. Também sou grato a Eric Kemp-Benedict, do Tellus Institute, que me proporcionou inestimável auxílio quando eu estava desenvolvendo o cenário global da energia no Capítulo 8.

Tive a oportunidade de efetuar análises de políticas energéticas e contribuir para programas energéticos no Brasil em várias ocasiões nos últimos 19 anos. O Capítulo 6 baseia-se em um estudo feito em colaboração com Roberto Schaeffer, Alexandre Szklo e Mauricio

Tolmasquim da Universidade Federal do Rio de Janeiro. Agradeço imensamente por seus comentários e auxílio. Também gostaria de agradecer a outros colegas brasileiros que me auxiliaram em todos esses anos, como José Alencar, José Goldemberg, Gilberto Jannuzzi, Paulo Leonelli, Marcos Lima, Regiane Monteiro de Abreu, Geraldo Pimentel e Paulo Cezar Tavares.

Manifesto minha gratidão a Nils Borg, Sivan Kartha, Roberto Lamberts, Benoit Lebot, Eric Martinot, Alan Miller, Isac Roizenblatt, Roberto Schaeffer e Michael Shepard por fornecerem informações úteis e/ou comentários sobre partes do trabalho. Meus agradecimentos especiais a José Roberto Moreira por realizar a revisão de quase todos os capítulos em sua fase inicial. Ao mesmo tempo que recebi um inestimável auxílio de todas essas pessoas, sou responsável por quaisquer erros ou omissões que tenham se mantido na tese.

Por fim, gostaria de agradecer a minha família – minha esposa Luci, minha filha Sara, meu filho Will – por seu estímulo e por seu amor. Sinto-me profundamente grato por sua paciência, compreensão e apoio durante as muitas noites e fins de semana que passei trabalhando neste livro.

Quadro: Unidades de Energia

O conteúdo energético dos combustíveis e de eletricidade é expresso em diferentes unidades em todo o mundo. As unidades que são utilizadas neste livro e sua equivalência com outras unidades de energia, são as seguintes:

quad (quadrilhões de Btu) = 1.055 EJ (exajoules)

tonelada do equivalente em petróleo(toe)=41.9 GJ(gigajoules)=39.7 milhões de Btu

barril de petróleo (bbl) = 6.1 GJ (gigajoules) = 5.8 milhões de Btu

tonelada do equivalente em carvão(tce)=29.3 GJ (gigajoules)=27.8 milhões de Btu

kilowatt-hora (kWh) = 3.6 MJ (megajoules) = 3,412 Btu

watt = 1 joule por segundo = 3.412 Btu por hora

O termo "*energia primária*" é utilizado algumas vezes neste livro. A energia primária inclui perdas na produção e distribuição de combustíveis e de eletricidade. Além dos valores expressos acima, os seguintes prefixos métricos são utilizados neste livro:

kilo (k) – 10^3 (milhar)

mega (M) – 10^6 (milhão)

giga (G) – 10^9 (bilhão)

tera (T) – 10^{12} (trilhão)

peta (P) – 10^{15} (quadrilhão)

exa (E) -- 10^{18}

Preface

I began writing this thesis in 1998 when energy was not a major issue. Energy prices were relatively low and declining. The United States and most other industrialized nations were experiencing robust economic growth and policy makers were grappling with an economic crisis in Asia. Global warming, however, was garnering international attention. With emissions of the gases causing global warming on the rise worldwide, nations joined together to limit future emissions by adopting the Kyoto Protocol. But it was far from clear how the industrialized nations could meet and then go beyond the Kyoto Protocol targets.

Much has transpired to raise the profile of energy issues since 1998. Oil prices climbed; Brazil experienced a severe electricity shortage; and the collapse of Enron affected financial markets and threatened political damage. In the United States, major energy policy initiatives were proposed by the Bush Administration and debated in the U.S. Congress. Meanwhile, terrorist attacks reminded us of the vulnerability of key components of our energy infrastructure.

This thesis comes at a critical juncture. Evidence of global warming keeps mounting. Some nations, regions, and companies have made significant progress in reducing their emissions of the gases causing global warming. Due in part to this trend, markets for cleaner energy technologies such as wind turbines, solar photovoltaic systems, and compact fluorescent lamps are booming. On the other hand, there are powerful forces pushing to maintain the status quo–continued heavy reliance on fossil fuels including coal and petroleum, and consequently rising greenhouse gas emissions and intensifying global warming.

Various other books and studies have suggested that a worldwide transition from fossil fuels to renewable energy sources coupled with greater energy efficiency–a clean energy revolution–is desirable and feasible. But most of these books and studies concentrate on the technologies for achieving this transition, not the strategies for deploying the technologies. I believe that the primary challenge is not technological. Most of the technologies for a clean energy revolution are either commercially available or emerging in the marketplace. The main challenge is how to overcome the barriers preventing widespread adoption these technologies in the coming decades; i.e., how to implement a clean energy revolution.

I wrote this thesis to help fill this gap. There has been a great deal of experience with policies for advancing energy efficiency and renewable energy supply over the past decade or two. Based on this experience, it is now possible to envision how an energy revolution could be accomplished during this century. This thesis reviews the policy experience so far and distills the lessons from past efforts to advance energy efficiency and renewable energy use. It also recommends and analyzes policies that could be adopted to facilitate a clean energy revolution in the future.

This thesis attempts to be holistic from a number of perspectives. First, it examines the range of economic, social and environmental threats posed by a "business-as-usual" energy future, and likewise the range of benefits offered by a clean energy revolution. Global warming is considered, but so are local and regional air pollution, security risks, resource depletion, and global equity. Second, it covers energy policy experience in both industrialized and developing nations, as well as experience at the local, state, national and international levels. In fact I have chosen to interweave the geographic coverage since leadership on implementing higher energy efficiency and renewable energy sources and thus important lessons have been provided by rich, middle income and poor nations alike. And third, it covers policies for advancing energy efficiency, renewable energy sources, and greater use of natural gas for a number of decades. All of these strategies are important elements of a potential clean energy revolution.

A word about energy units. I have chosen to use the conventional energy units from a particular country or region; e.g., quadrillion Btus (quads) in the United States, million tons of oil equivalent in Brazil, and million tons of coal equivalent in China. These units are familiar to the readers in each region. The box at the end of the preface presents energy conversion factors.

I am indebted to many individuals who assisted me during the journey that culminated in this thesis. First, I would like to thank Professor José Goldemberg for serving as my advisor and providing support and encouragement. Second, I would like to thank the other members of my thesis committee including Gilberto Jannuzzi, José Roberto Moreira, Arthur Rosenfeld, and Roberto Schaeffer. Third, I would like to thank David Zylbersztajn who proposed that I become a Ph.D. candidate at USP about 10 years ago and helped to arrange this. Fourth, I am grateful to Maria Cristina Vidal Borba and Rafael Mantovani for their high quality translation.

The thesis builds on a number of studies I led or participated in while serving as Executive Director of the American Council for an Energy-Efficient Economy (ACEEE) in Washington, DC. Chapter 5 draws from previous collaborations with Steven Nadel in particular but also John DeCicco, Neal Elliott, Toru Kubo, and Jennifer Thorne of ACEEE. I am grateful for their valuable contributions.

The integrated policy analysis in Chapter 5 was provided by Allison Bailie, Steve Bernow, and Bill Dougherty of the Tellus Institute in Boston, MA under my direction. I greatly appreciate their careful and thoughtful analytical work for this study as well as other joint efforts over the years. In addition, Eric Kemp-Benedict of the Tellus Institute provided valuable assistance as I was developing the global energy scenario in Chapter 8.

I have had the opportunity to carry out energy policy analysis and contribute to energy programs in Brazil at various times during the past 19 years. Chapter 6 is based on a collaborative study with Roberto Schaeffer, Alexandre Szklo, and Mauricio Tolmasquim from the Federal University of Rio de Janeiro. I greatly appreciate their insights and assistance. I also want to thank other Brazilian colleagues who helped me over the years including José Alencar, José Goldemberg, Gilberto Jannuzzi, Paulo Leonelli, Marcos Lima, Regiane Monteiro de Abreu, Geraldo Pimentel, and Paulo Cezar Tavares.

I am grateful to Nils Borg, Sivan Kartha, Roberto Lamberts, Benoit Lebot, Eric Martinot, Alan Miller, Isac Roizenblatt, Roberto Schaeffer, and Michael Shepard for providing useful information and/or helpful comments on portions of the manuscript. I would especially like to thank José Roberto Moreira for carefully reviewing nearly all of the chapters in draft form. While I received valuable assistance from all these individuals, I am responsible for any errors or omissions remaining in the thesis.

Finally, I would like to thank my family–my wife Luci, daughter Sara, and son Will–for their encouragement and love. I greatly appreciated their patience, understanding, and support during the many evenings and weekends spent working on this thesis.

BOX: Energy Units

The energy content of fuels and electricity is expressed in different units around the world. The units that are used in this thesis, and their equivalence to other energy units, are as follows:

quad (quadrillion Btu) = 1.055 EJ (exajoules)

ton of oil equivalent (toe) = 41.9 GJ (gigajoules) = 39.7 million Btu

barrel of oil (bbl) = 6.1 GJ (gigajoules) = 5.8 million Btu

ton of coal equivalent (tce) = 29.3 GJ (gigajoules) = 27.8 million Btu

kilowatt-hour (kWh) = 3.6 MJ (megajoules) = 3,412 Btu

watt = 1 joule per second = 3.412 Btu per hour

The term "primary energy" is used at times in this thesis. Primary energy includes losses in the production and delivery of fuels and electricity. In addition, the following metric prefixes are used in this thesis:

kilo (k) – 10^3 (thousand)

mega (M) – 10^6 (million)

giga (G) – 10^9 (billion)

tera (T) – 10^{12} (trillion)

peta (P) – 10^{15} (quadrillion)

exa (E) -- 10^{18}

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Inserts for final changes to Portuguese version of *Energy Revolution*

Insert for p. 13

Even if these catastrophic events do not occur, increasing carbon dioxide emissions and sustained global warming inevitably would result in both melting of the polar ice sheets and ocean thermal expansion over the course of many centuries. This in turn would result in sea level rise of at least a number of meters during the next thousand years or so. The impact is delayed because of the time lags between global warming and sea level rise, but is "wired in" by elevated temperature levels in the nearer term (Mahlman 2001). Sea level rise of this magnitude would inundate vast areas and present enormous challenges to humankind.

Insert for p. 18

There are also substantial disparities in energy use within countries, both industrialized and developing nations. In the United States, for example, wealthier households consumer about 75 percent more energy than poorer households. Likewise, urban households in China's four richest coastal provinces consume about two and a half times as much energy as households in poorer interior provinces. Similar differences are found in other countries including Brazil, India, and Mexico (Smil 2000).

Insert for p. 41

The poor quality of energy audits and other energy efficiency services has been noted in a number of countries. For example, the quality of home energy audits and improper installation of efficiency measures has been identified as problems in the United Kingdom (Crowley 2001). Also, the poor quality of industrial energy audits has been noted as a barrier to energy efficiency improvement in Thailand. (Vongsoasup et al. 2002).

Insert for p. 87

The New York Power Authority (NYPA) is using bulk procurement to replace older refrigerators in 180,000 apartments occupied by low-income households in New York City. NYPA is reimbursed by the city's housing authority, which pays the electric bills for these households. In response to the bulk purchase offer, one appliance manufacturer developed a new refrigerator model that consumes about 60 percent less electricity than typical older models found in these apartments. Older refrigerators are collected and their materials are recycled as part of this program (Kinney and Cavallo 2000).

Insert for p. 97

Along with renewable energy requirements, energy suppliers can be required to achieve specified levels of end-use energy savings. For example, the national energy regulatory agency in Italy is requiring electricity and gas distributors to achieve predetermined energy savings targets during 2002-06. The savings targets can be met either through energy efficiency programs or purchase of tradable energy efficiency certificates from energy service companies (Pavan 2002). A similar energy savings obligation has been imposed on energy suppliers in the United Kingdom.

Insert for p. 148:

The PROINFA policy adopted in 2002 requires the electric sector to pay 80 percent of the average retail electricity price for biomass cogeneration projects (as well as wind and small-scale hydro projects) over a 15-year period. Also, the national development bank launched a low-interest loan program for biomass cogeneration projects in 2001. These new policies are expected to result in considerable investment in more efficient bagasse cogeneration systems in ethanol distilleries (Moreira 2002).

Full adoption of higher pressure boilers, more efficient steam turbines, and year-round operation could result in about 31 TWh of biomass-based electricity generation by ethanol distilleries. This is nearly eight times more electricity than they generated as of 2000 (Moreira, Goldemberg, and Coelho 2002).

Insert for p. 271:

In addition, California enacted legislation in 2002 that directs state officials to establish CO_2 emissions standards on new cars and light trucks effective in 2009 (Hakim 2002). This action, which was strongly opposed by most auto companies, could force auto manufacturers to significantly improve the average fuel efficiency of new cars and light trucks.

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Change Winrock International 1999 to Winrock International 2002. The title and name/place of publication remain the same.

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