Planejamento, gestão e as grandes questões ainda por responder no campo da Energia

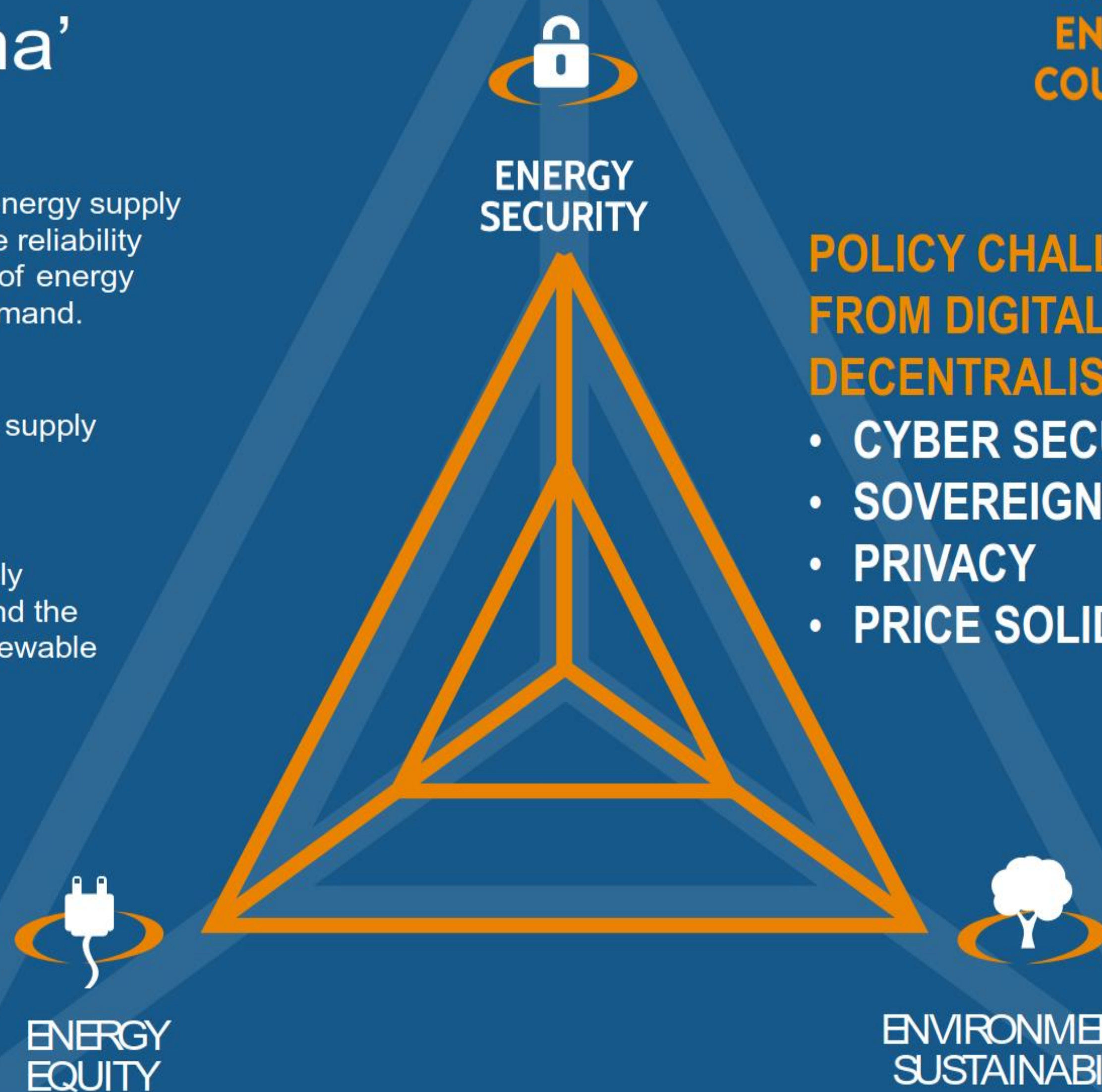
Um histórico sobre o planejamento no setor elétrico brasileiro

Balancing the 'Energy Trilemma'

Energy Security
The effective management of primary energy supply from domestic and external sources, the reliability of energy infrastructure, and the ability of energy providers to meet current and future demand.

Energy Equity
Accessibility and affordability of energy supply across the population.

Environmental Sustainability
Encompasses the achievement of supply and demand side energy efficiencies and the development of energy supply from renewable and other low-carbon sources.



WORLD ENERGY COUNCIL

POLICY CHALLENGES FROM DIGITAL- & DECENTRALISATION

- CYBER SECURITY
- SOVEREIGNTY
- PRIVACY
- PRICE SOLIDARITY

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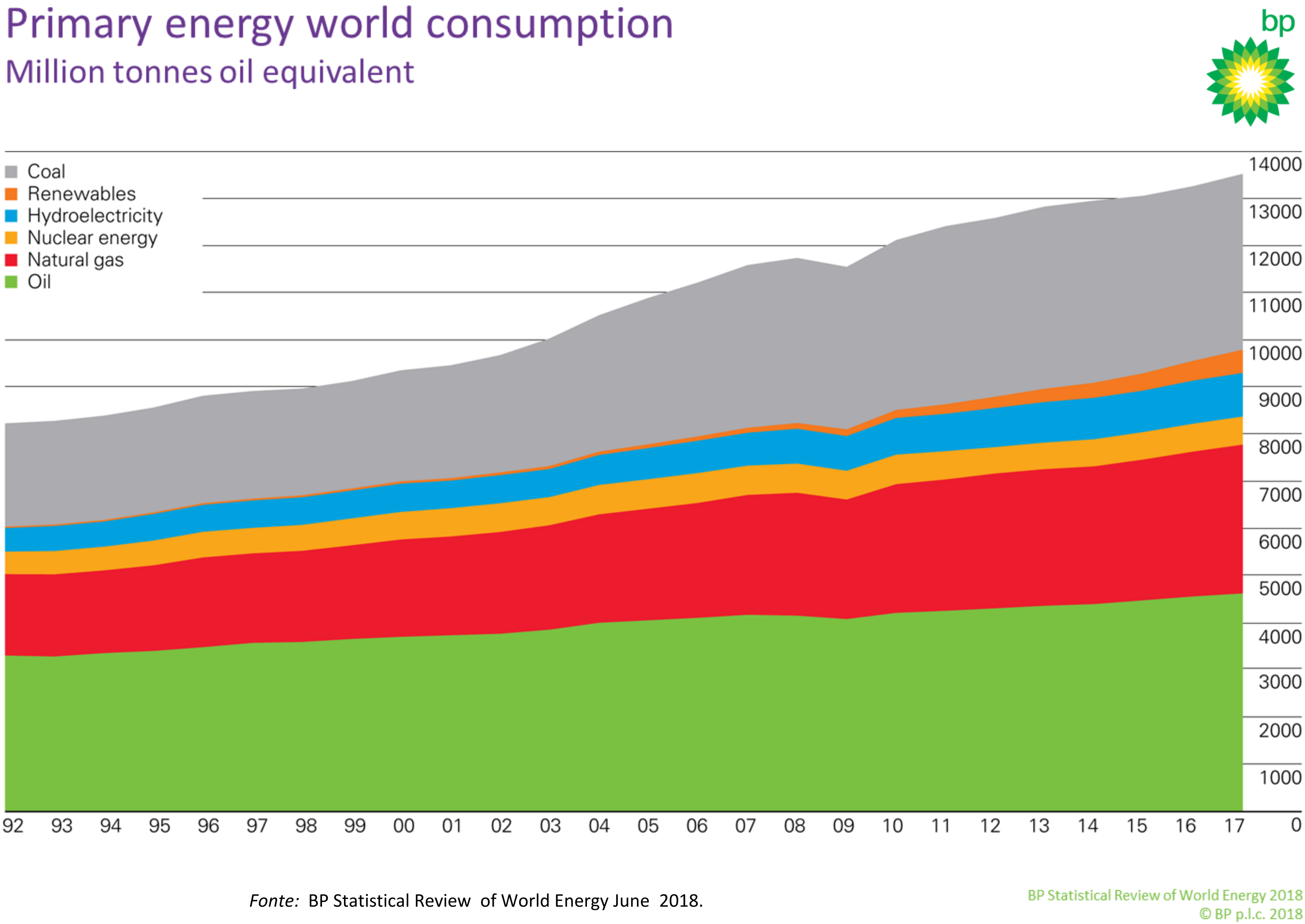
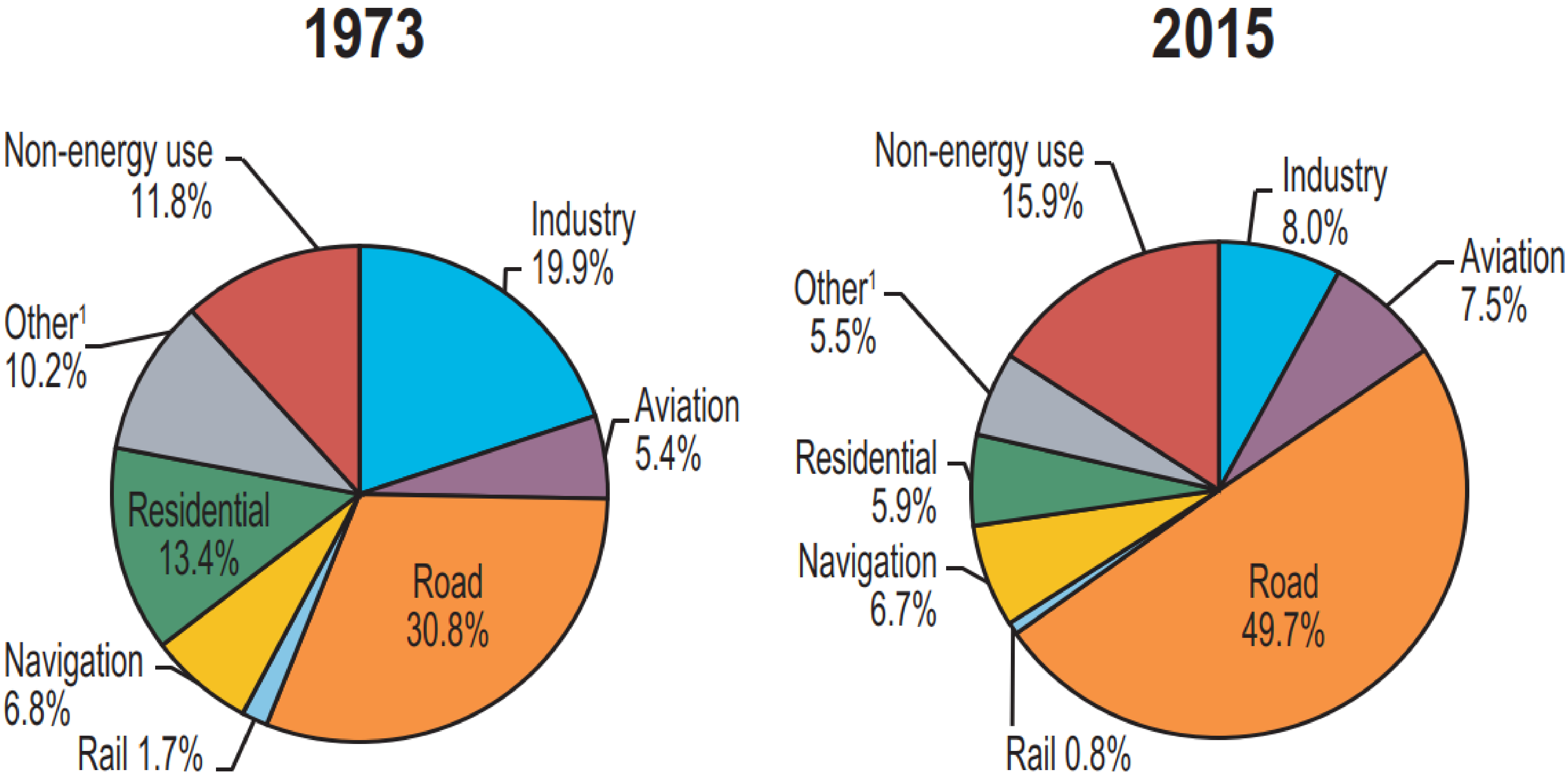
Energia para que? – Dependência de combustíveis fósseis



Fonte: BP Statistical Review of World Energy June 2018.

Energia para que? - Consumo setorial mundial de petróleo (2015)

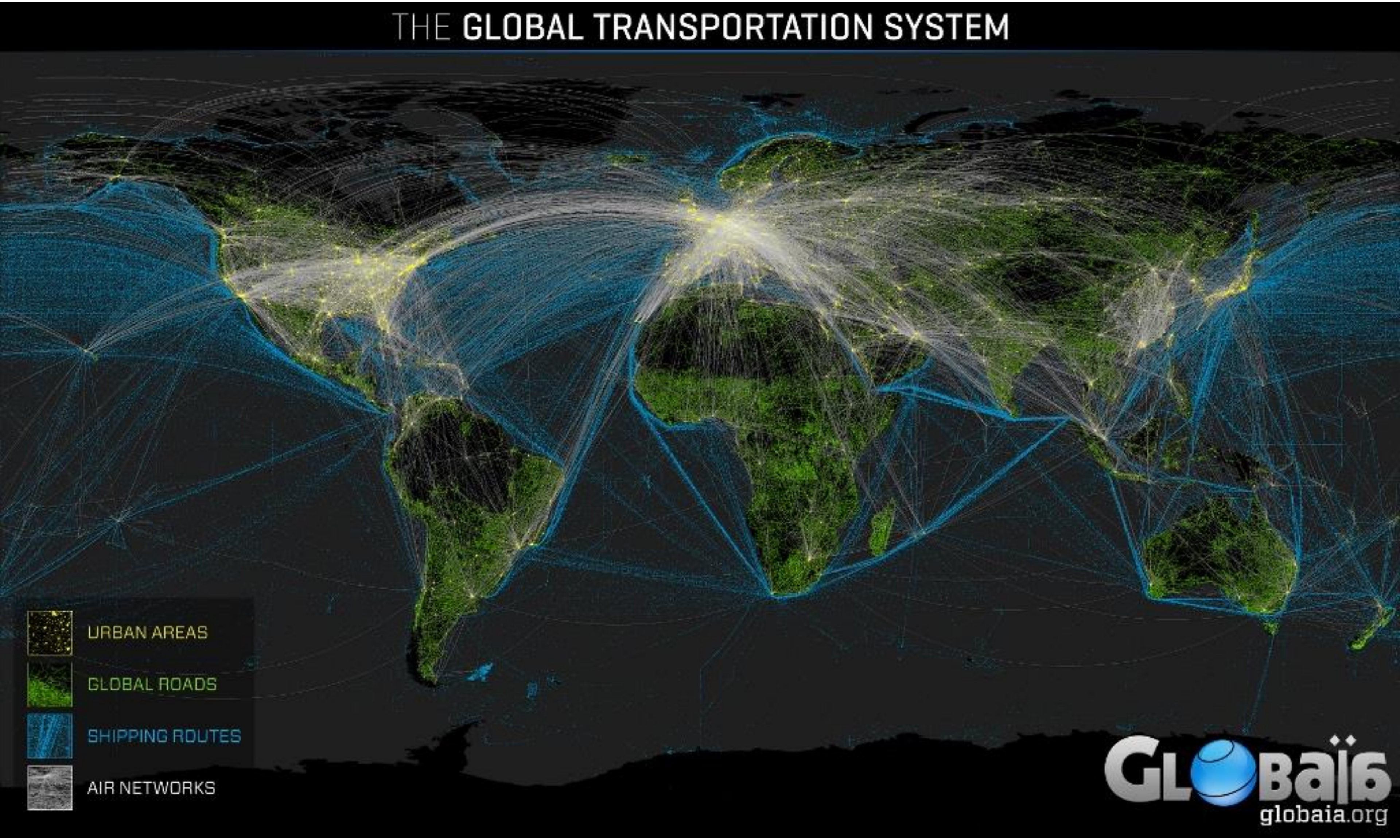


2 252 Mtoe

3 840 Mtoe

Fonte: OECD/IEA, Key World Energy Statistics 2017.

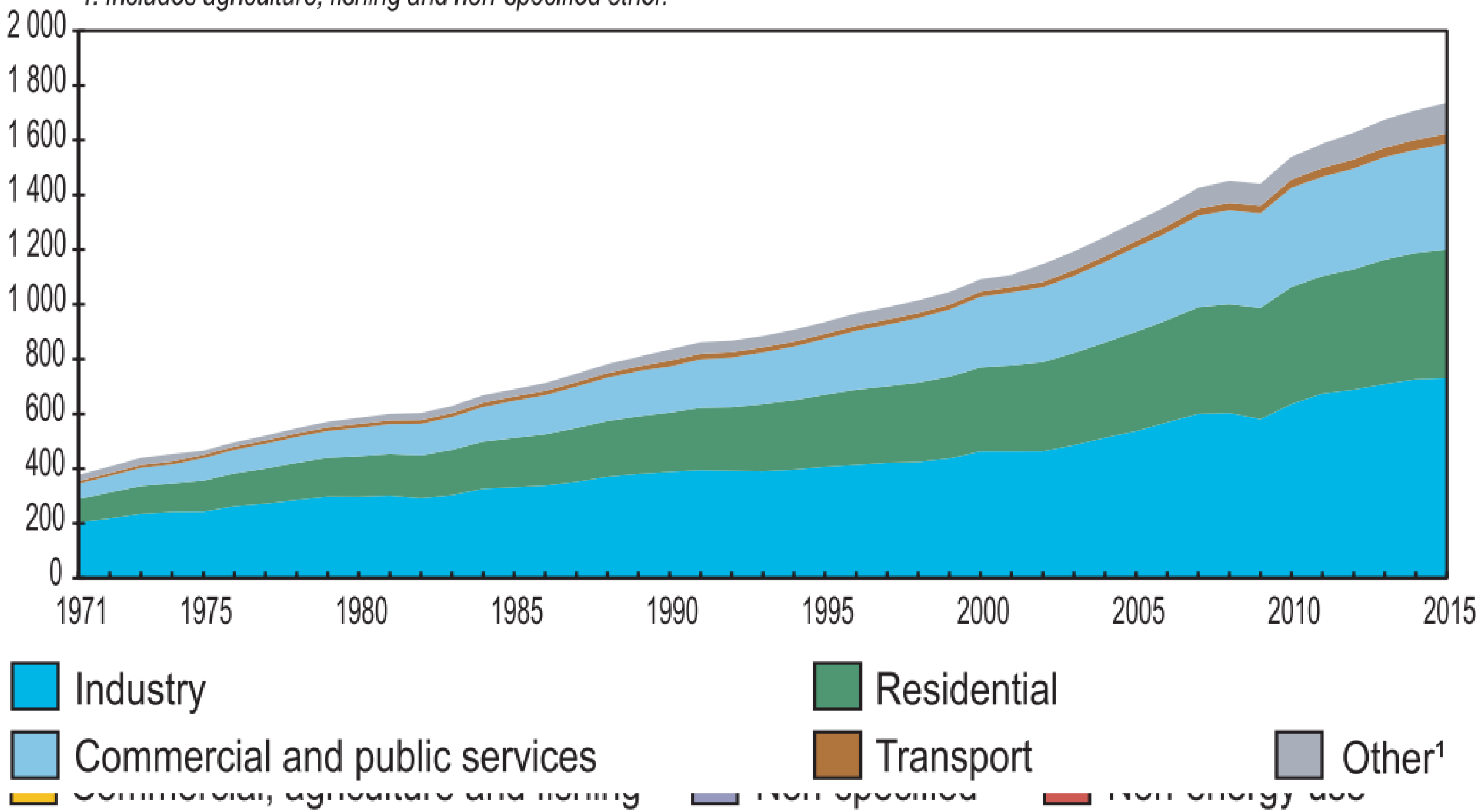
Energia para que? - Sociedade industrial e urbana



Energia para que? - Consumo final mundial de energia 1ª (setor)

Electricity TFC from 1971 to 2015 by sector (Mtoe)

1. Includes agriculture, fishing and non-specified other.



Fonte: IEA Key World Energy Statistics 2017.

Energia para que? – Indústria e uso de energia

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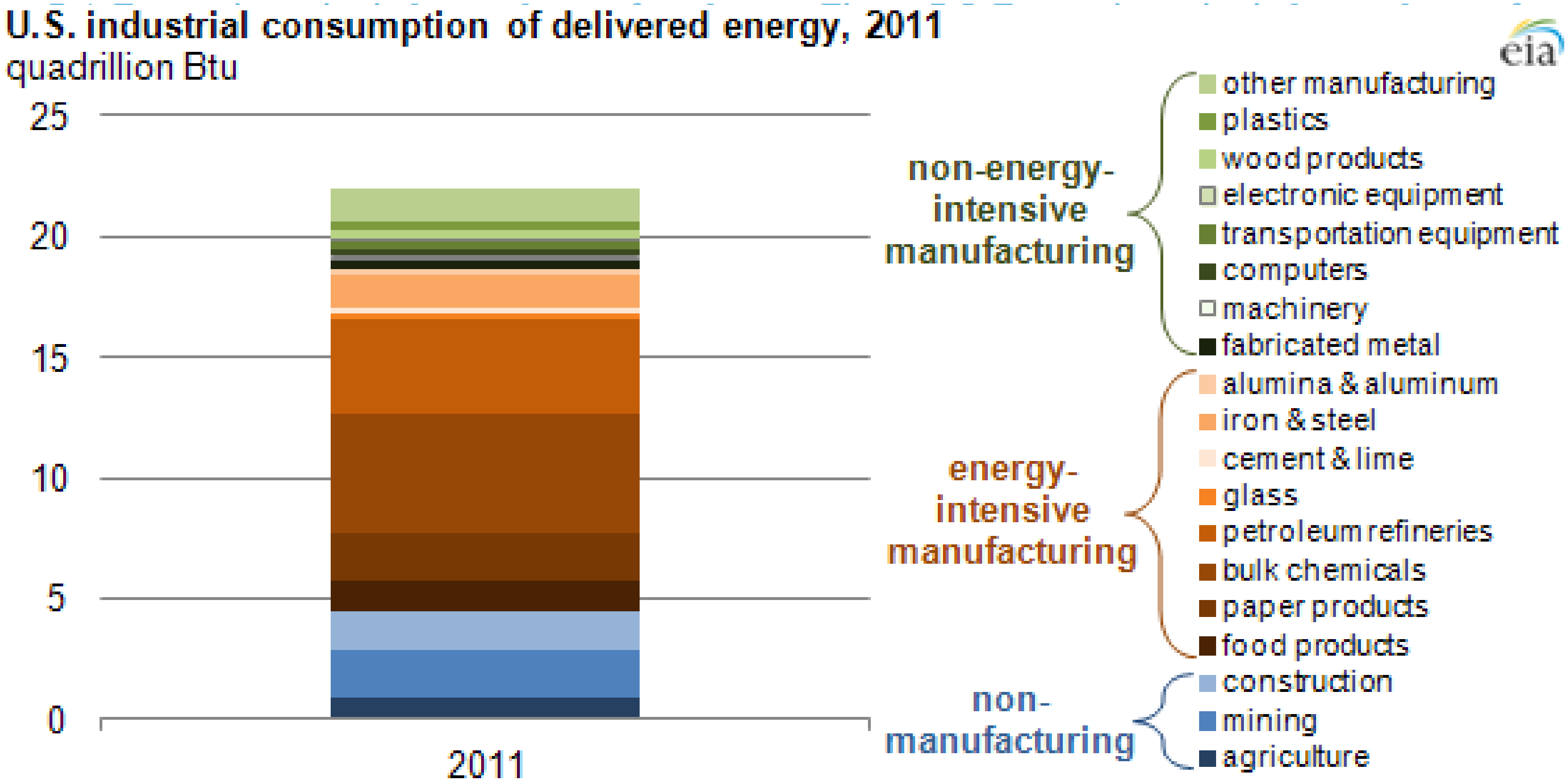


N

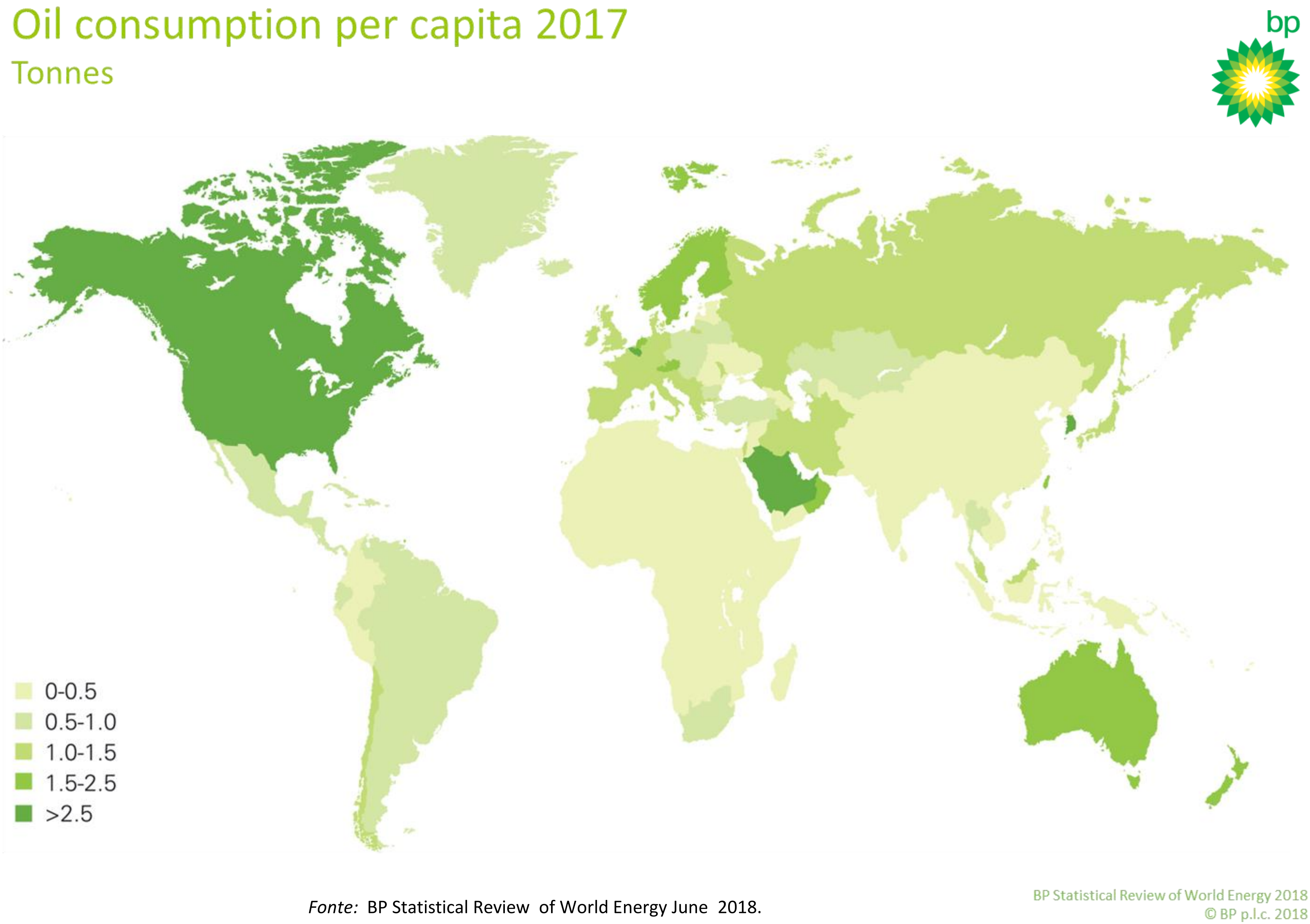
Non

20

117

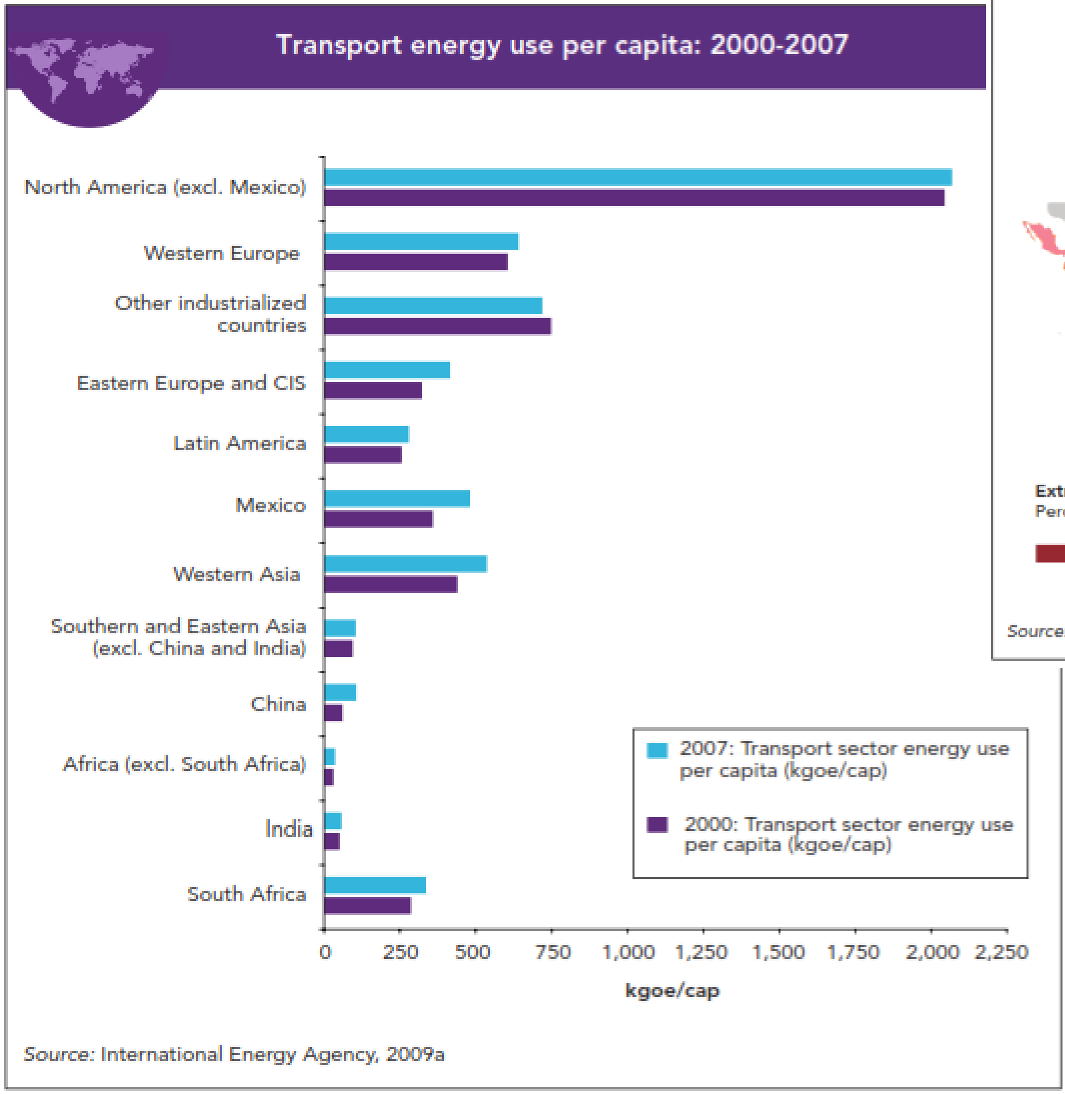
Fonte: US EIA International Energy Outlook, 2016.

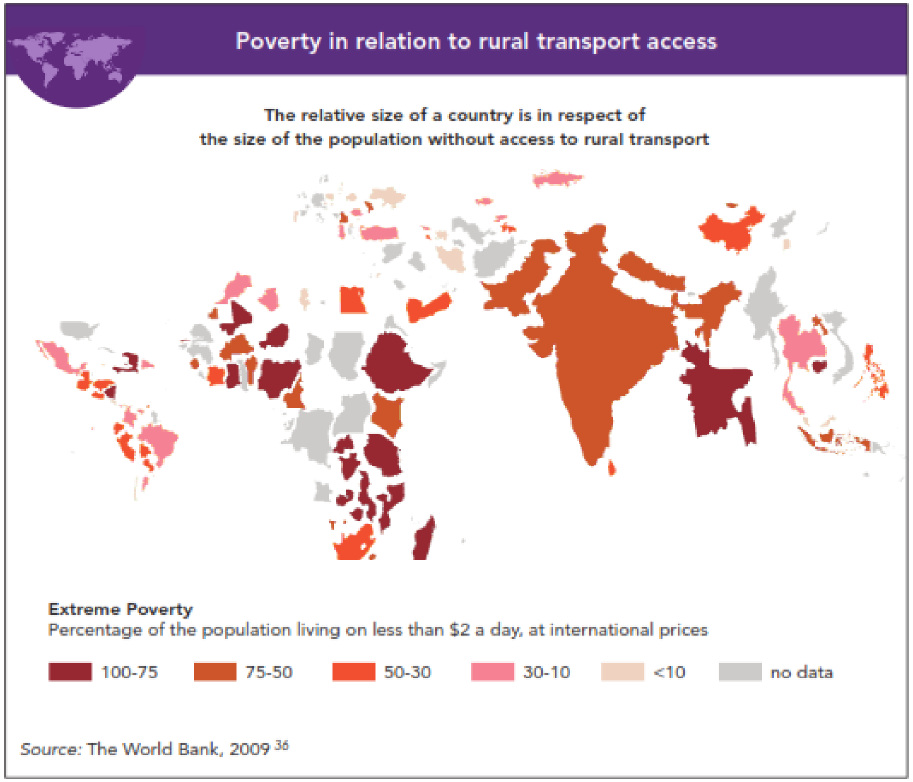
Energia para quem? - Consumo per capita de petróleo



Fonte: BP Statistical Review of World Energy June 2018.

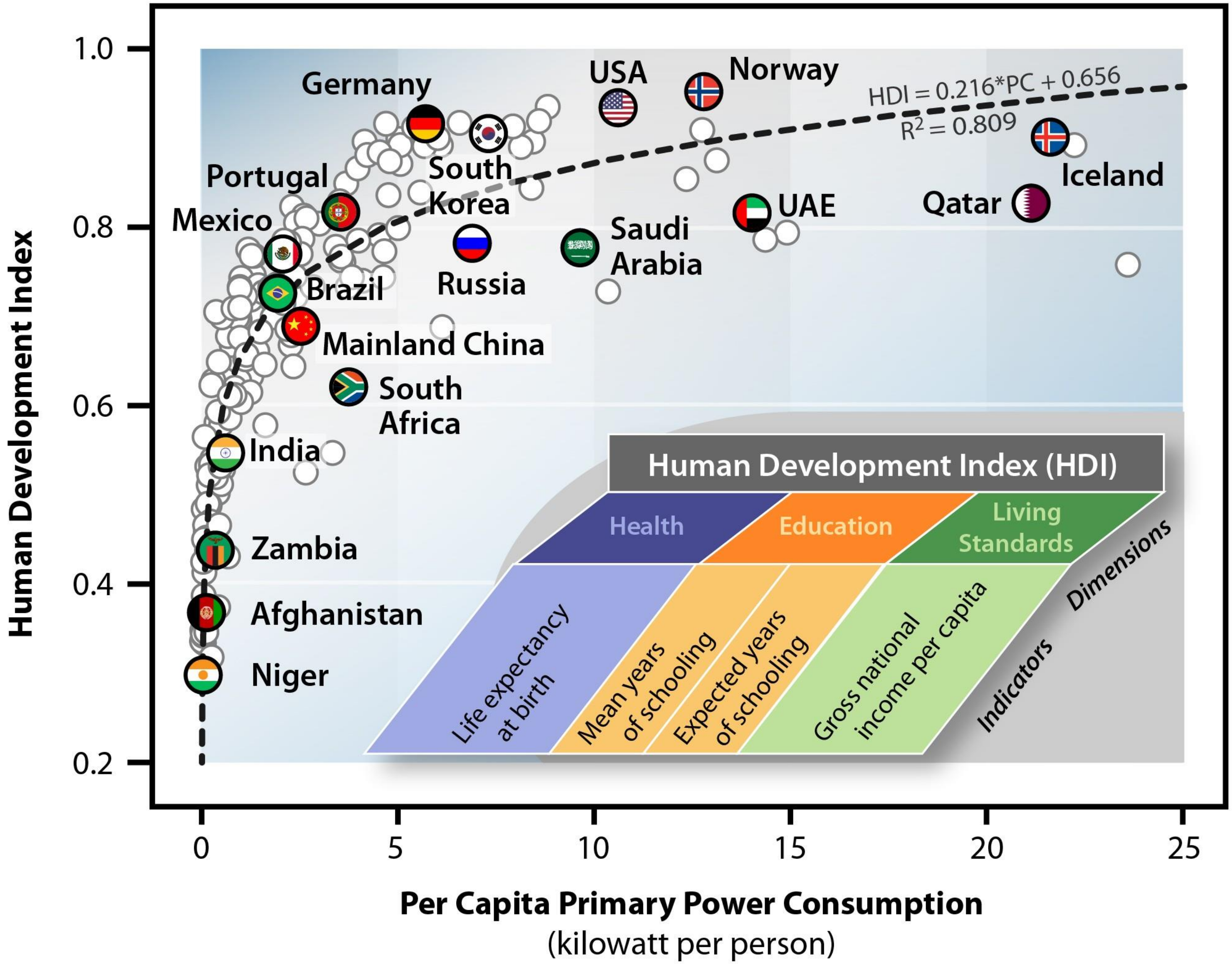
Transporte, Sociedade, desigualdade, exclusão





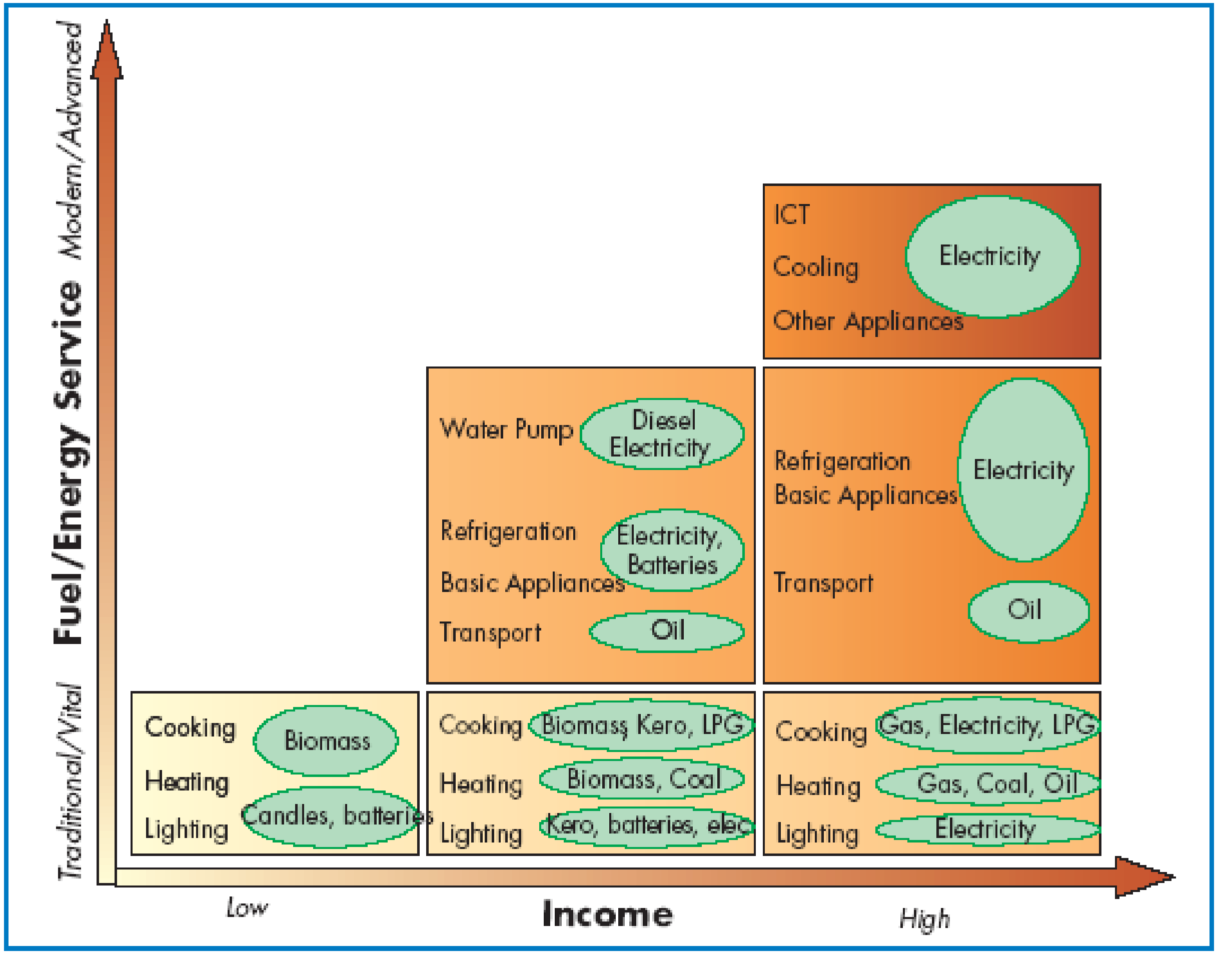
Fonte: UN/DESA, 2010. Trends in Sustainable Development – Chemicals, Mining, Transport, Waste Management 2010-2011.

Energia para quem? – Exclusão x desenvolvimento



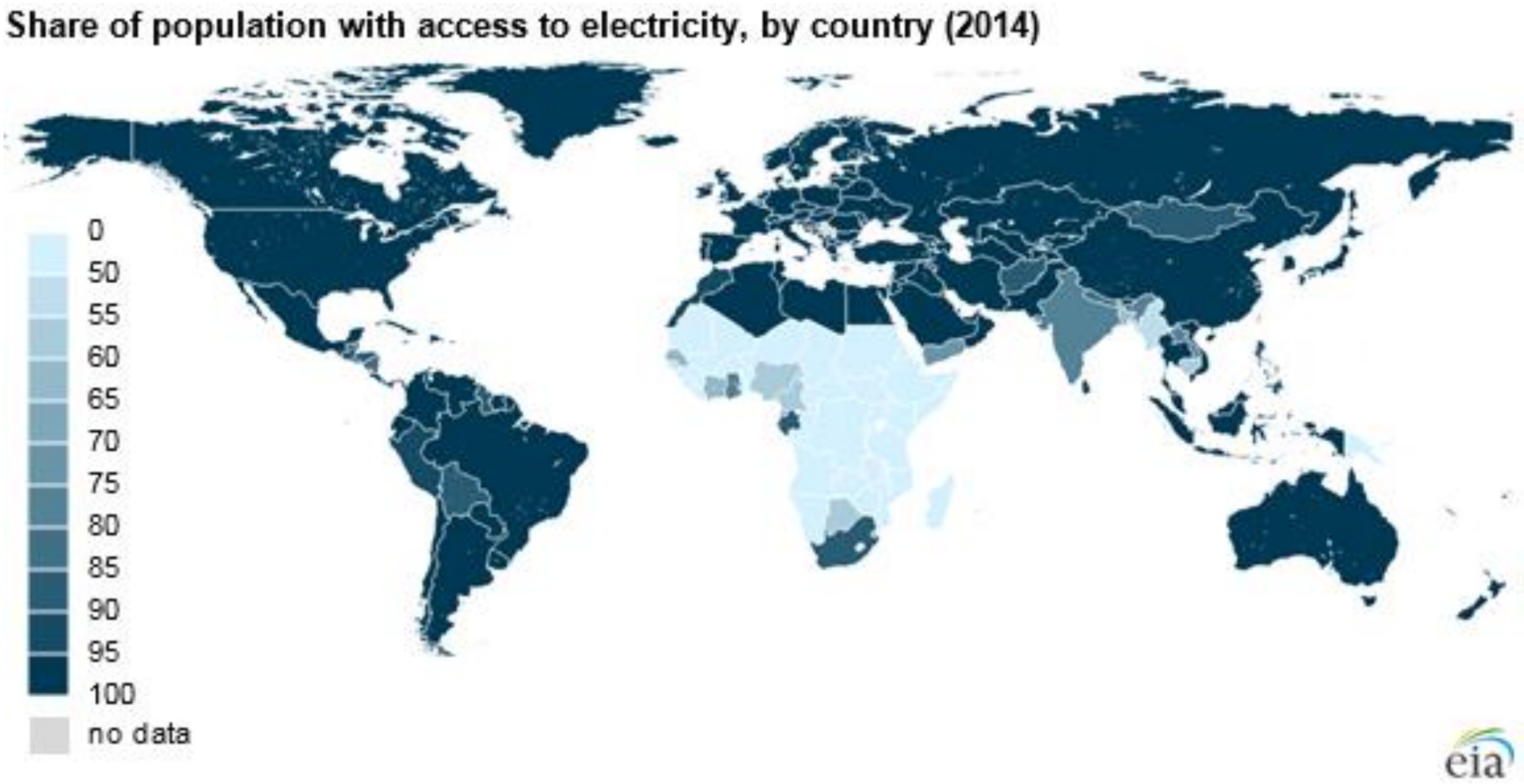
Fonte: Dale, B., 2014 (ourenergypolicy.org)

Energia para quem? – Exclusão x Energia



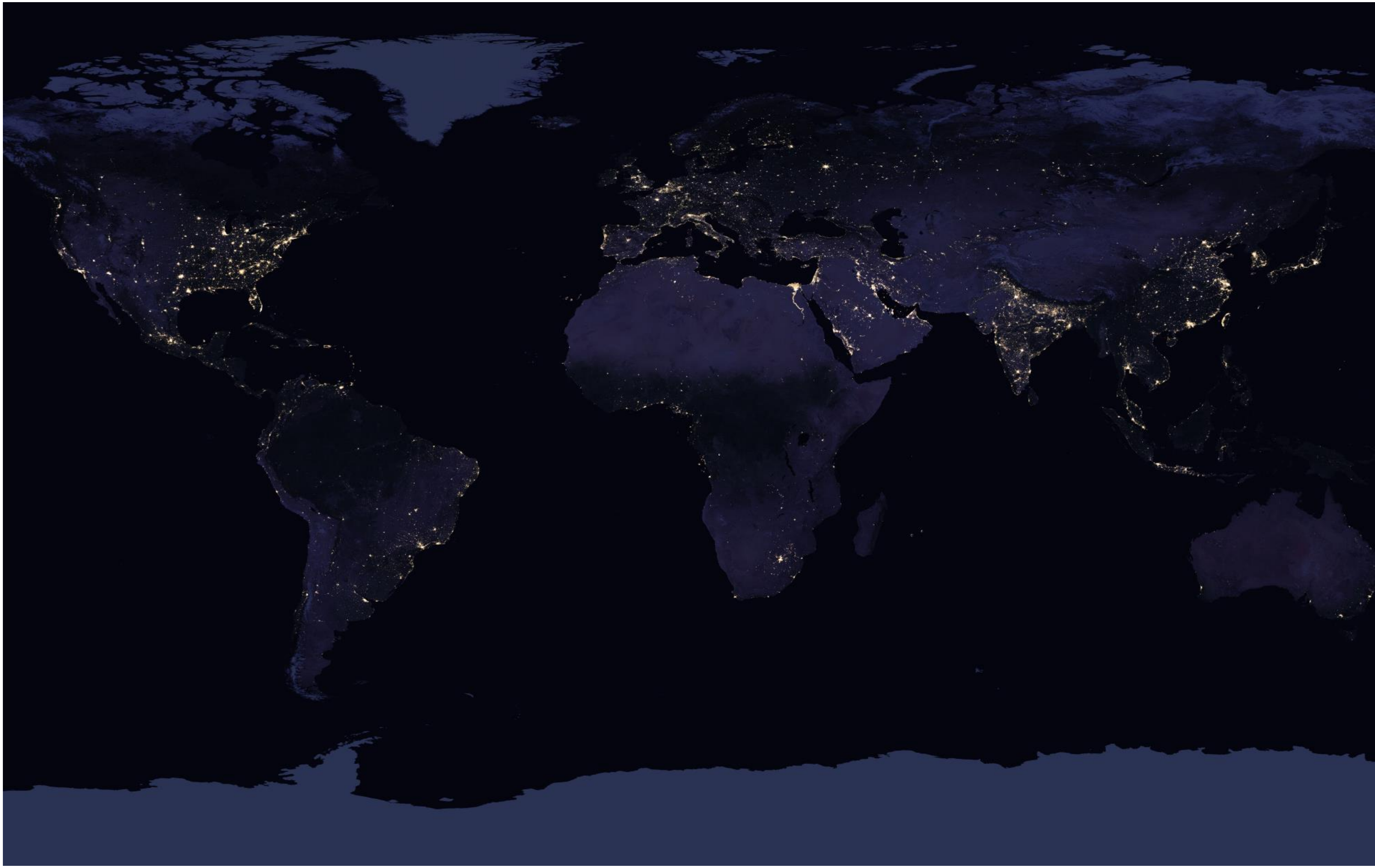
Note: ICT is information and communication technology.
Source: IEA analysis.

Energia para quem? – Exclusão x Energia



Fonte: Energy Information Administration, June 2017.

Energia para quem? - Desigualdade, exclusão e suas formas



Fonte: NASA, 2016 (https://tinyurl.com/mh8abrg).

Energia para quem? – Exclusão, energia e gênero

Fonte: Water Aid / Layton Thompson, 2010.

Pobreza energética direta – "fuel poverty"

Definitions

- UK (2001-2013):

"A household is said to be in fuel poverty if it **needs** to spend more than 10% of its income on fuel to maintain an adequate level of warmth"

- England (new LIHC 2013-):

A household is said to be in fuel poverty if it

1. has required fuel costs that are above average (the national median level)
2. were they to spend that amount, they would be left with a residual income below the official poverty line (60% median income)

- Ireland (2007-):

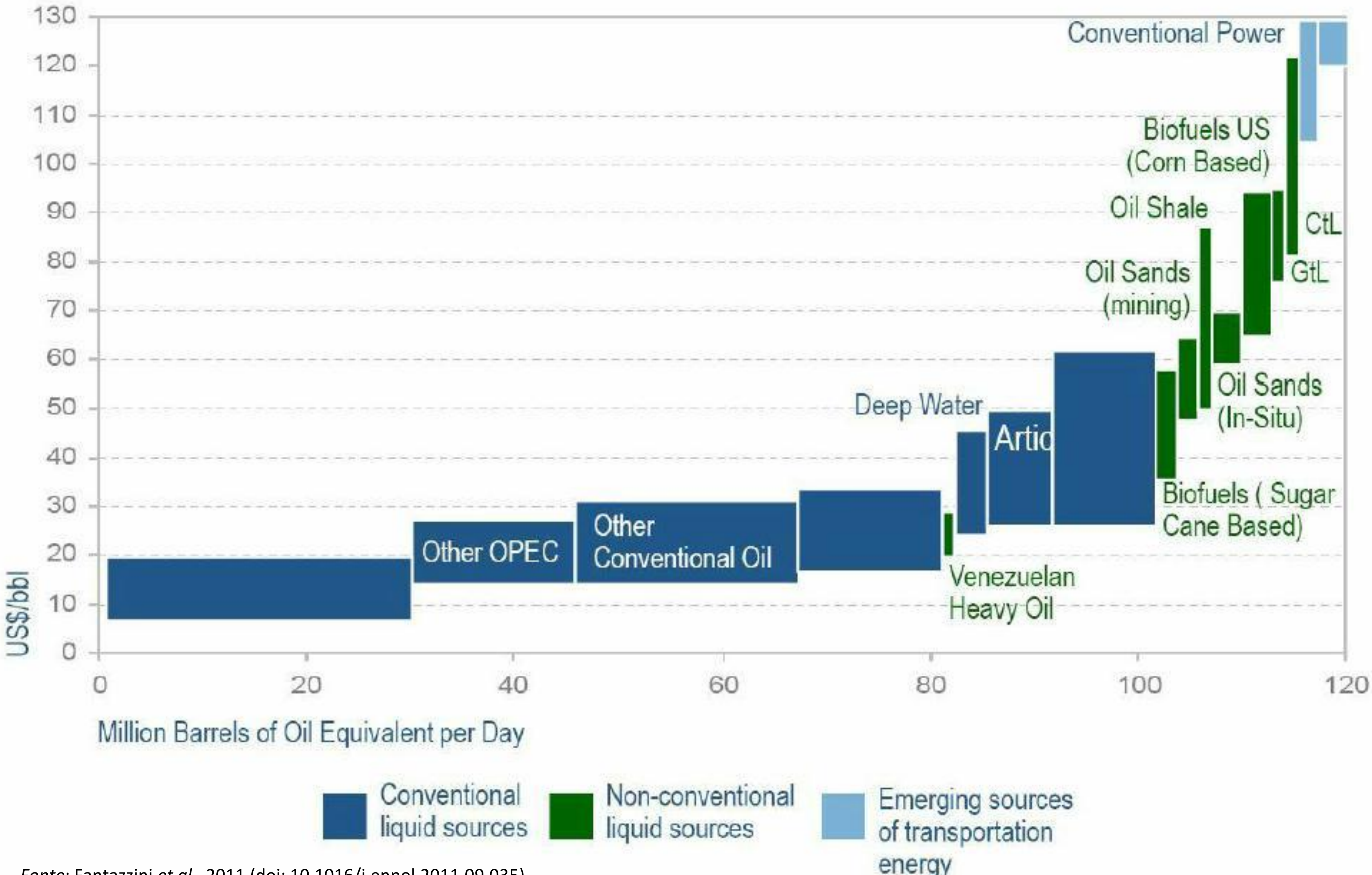
"the inability to afford adequate warmth in a home, or the inability to achieve adequate warmth because of the energy inefficiency of the home"

- France (2009-):

A person is considered fuel poor "if he/she encounters particular difficulties in his/her accommodation in terms of energy supply related to the satisfaction of elementary needs, this being due to the inadequacy of financial resources or housing conditions"

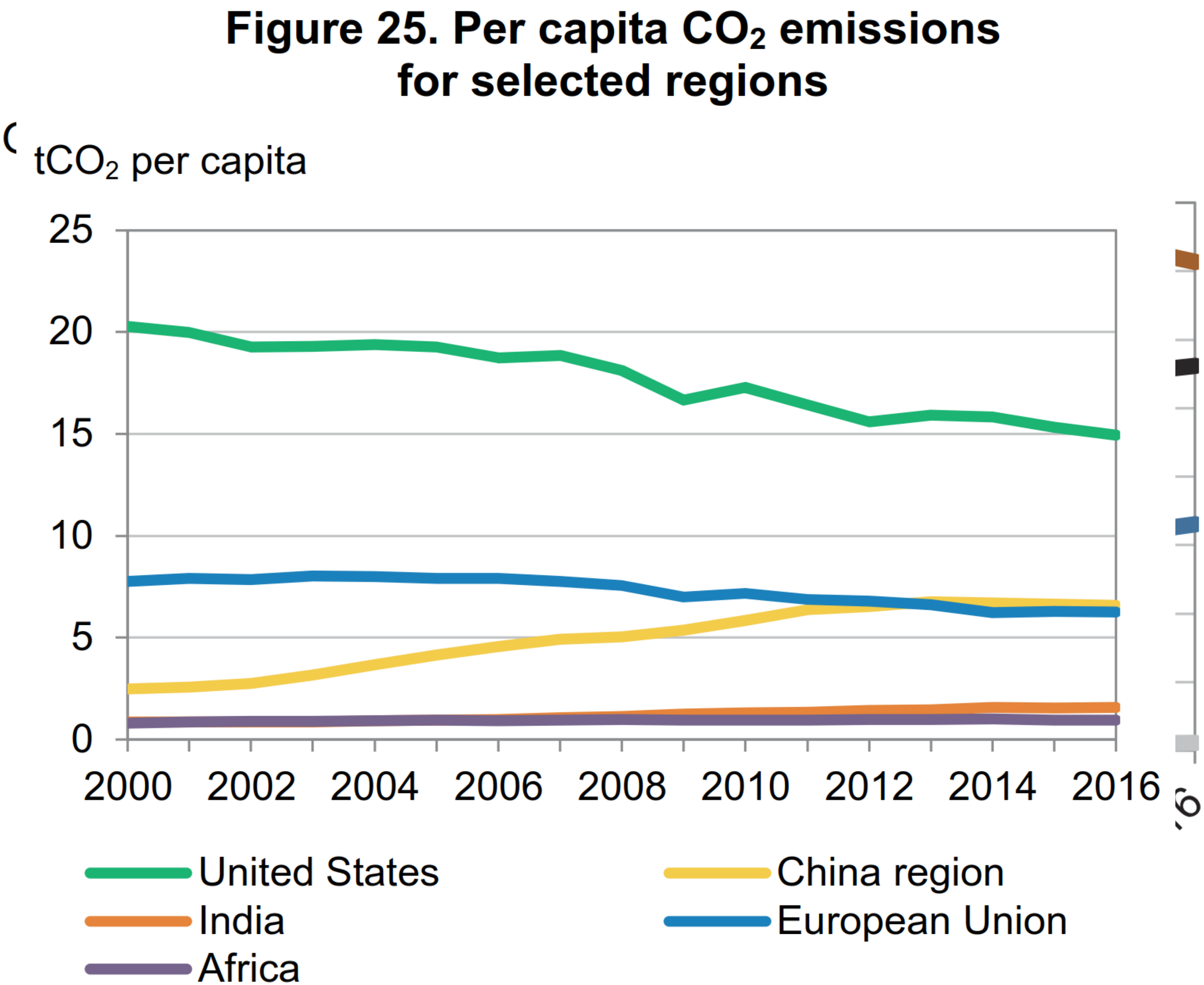
Fonte: Thomson and Bouzarovski, 2016.

Energia como? – A que custo e a que "custas"?

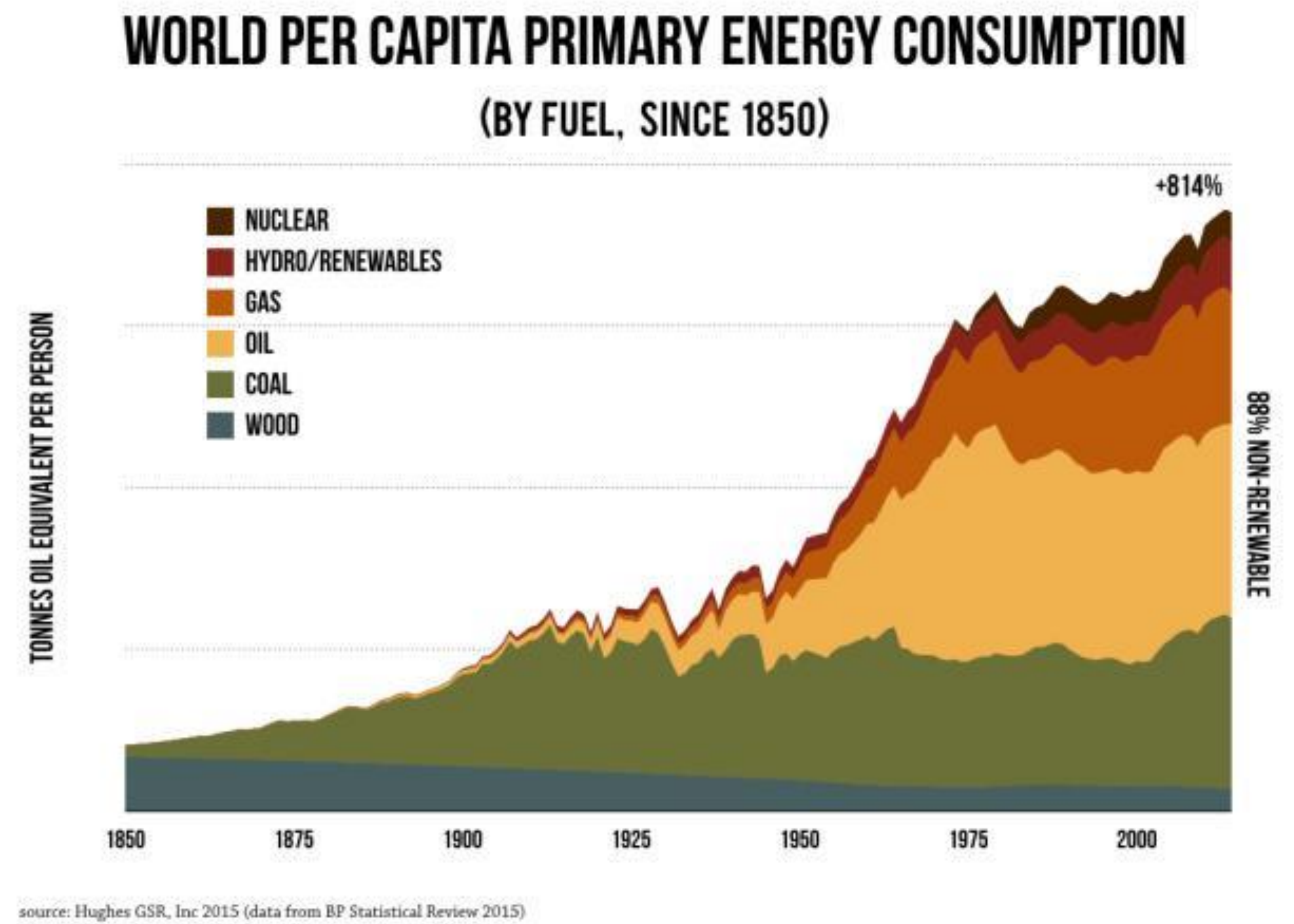


Fonte: Fantazzini *et al.*, 2011 (doi: 10.1016/j.enpol.2011.09.035)

Energia como? – A que custo e a que “custas”?



Energia como? – A que custo e a que "custas"?



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Planejamento – por quê?

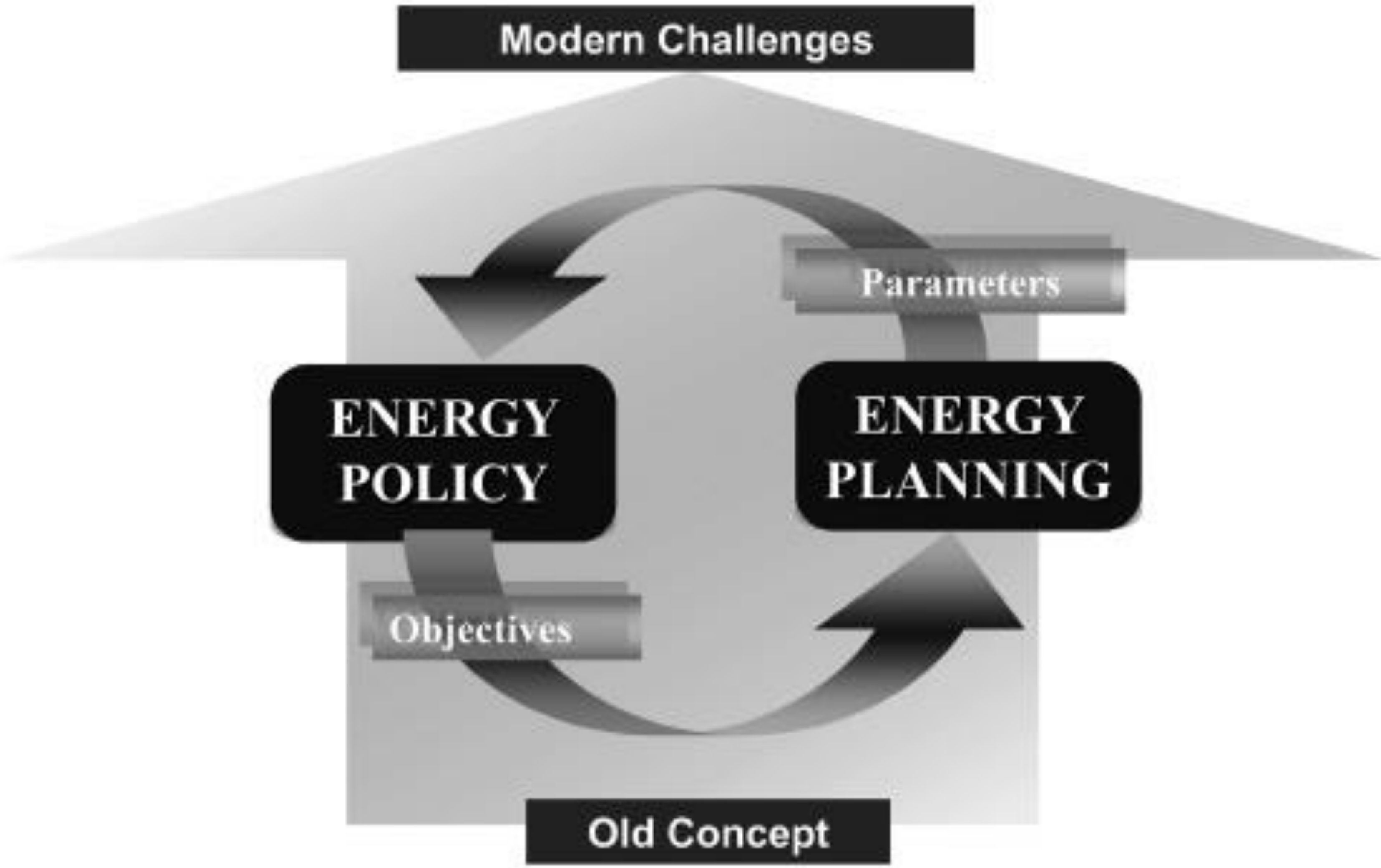
✓ Racionalização dos interesses
- Estratégicos
- Conflitantes

✓ Origem no Iluminismo e na Revolução Científica

✓ Planejamento econômico
- Crises no “Entre Guerras”
- Crash de 1929
- Racionalização da economia para superar as falhas e desequilíbrios

✓ Planejamento energético
- Maior relevância a partir dos 1970s

Planejamento – por quê?



Fonte: Doukas *et al*.,, 2008 (DOI: 10.1080/15567240701232378).

A importância do planejamento com uma visão sistêmica

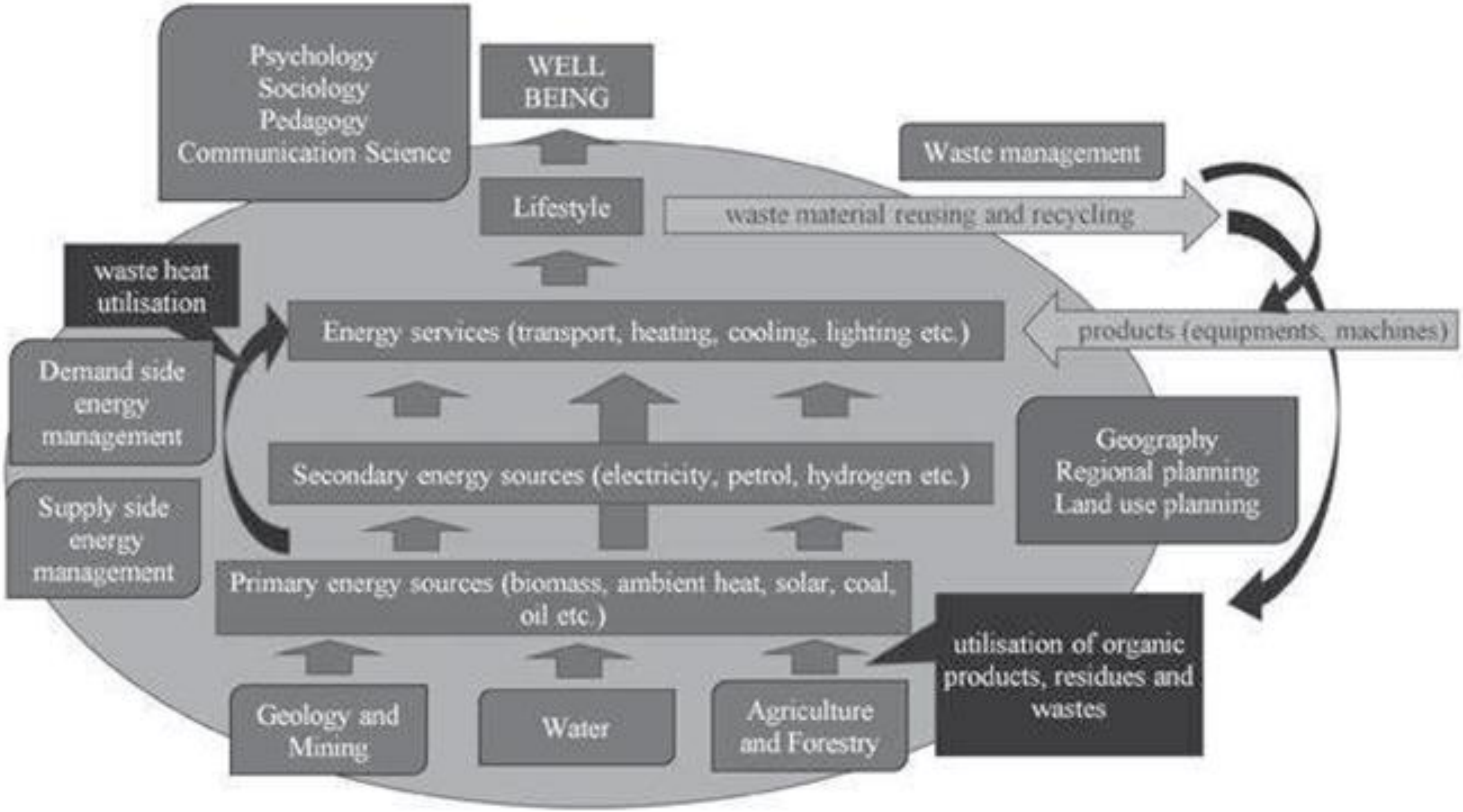


Figure 3 – Holistic approach of energy planning and management

Edited by MUNKÁCSY, B. (2013)

Fonte: Munkácsy, 2013.

COMMENT

DIETER TELEMANS/PANOS

Masai women from Kenya take a course on solar energy in India.

Energy studies need social science

A broader pool of expertise is needed to understand how human behaviour affects energy demand and the uptake of technologies, says **Benjamin K. Sovacool**.

To secure a safe, reliable and low-carbon energy future, we must alter both technologies and human behaviour[1]. The US Department of Energy notes[2] that supply and demand is "affected as much by individual choice, preference, and behavior, as by technical performance".

Yet many researchers and policy-makers continue to focus on only one side of the energy dilemma. In the United States, for every dollar in research funds spent on behavioural and demand-side energy research, $35 is spent on energy supply and infrastructure[3]. Social sciences, humanities, and the arts are marginalized in energy research, and major statistical agencies do not usually collect qualitative data about energy consumption. Similar problems are apparent in Europe[4].

My analysis of the peer-reviewed energy-research literature shows how biases handicap the field[5]. Engineers and economists are ignoring people and miscasting decision-making and action. Academic researchers frequently obsess over technical fixes rather than ways to alter lifestyles and social norms[6]. Interdisciplinary research remains stymied by institutional barriers in academia and government[7]. National and local energy bodies have conventionally had few social scientists on staff[8]. And most leading journals in the field focus on one discipline.

Now the energy field needs to learn from health, agriculture and business, and bring together social and physical scientists. Universities should develop courses focused on solving energy problems, granting agencies should prioritize and direct more money to behavioural work, and energy journals should broaden their scope. Already, there are promising examples of how inclusive and interdisciplinary energy research can encourage energy efficiency, and so address global environmental challenges such as climate change[9].

I examined the authorship and scope of 4,444 full-length articles over 15 years (1999 to 2013) in three leading energy technology and policy journals: *Energy Policy* and *The Energy Journal* have high impact factors, and *The Electricity Journal* was included to sample a regulatory journal. I found four worrisome trends: an undervaluation of the influence of social dimensions on energy use; a bias towards science, engineering and economics over other social sciences and the humanities; a lack of interdisciplinary collaboration; and the under-representation of female authors or those from minority groups.

For instance, technology adoption, the complexity of choice-making, and the human dimensions of energy use and environmental change were rarely covered (see 'Neglected topics'). Most articles (85%) focused on advanced energy-production systems, such as nuclear reactors, sources of renewable electricity and biofuels, or the technical elements of electricity generation, transmission and distribution — hardware — rather than the human 'software' behind it. Simple devices such as cooking stoves, bicycles, light bulbs and distributed generation were studied in less than 3.5% of articles. Behaviour and energy demand was investigated in less than 2.2% of papers. If this work is being published, it is in environmental sociology, psychology and political-science journals that few energy researchers read.

SOCIAL OUTCASTS

Social-science authorship and citations are also relatively low (see 'Publishing trends'). Science, engineering, economics and statistics account for more than half (67%) of institutional affiliations as reported by authors; non-economic social science for less than 20%. Sociology, geography, history, psychology, communication studies and philosophy each constituted less than 0.3% of author affiliations.

References to social-science and humanities journals, with their insights into how consumers and politicians behave, were less than 4.3% of 90,097 citations across the sample. Little research took place in the 'real world'. Most studies are the result of work undertaken at the bench or desk using computer models and experiments, rather than field research, interviews and surveys.

Another trend is that the scientists and engineers writing in these journals rarely collaborate beyond their fields. About half of published authors in the sample wrote alone and one-quarter published with colleagues within their discipline. Less than 23% of articles involved interdisciplinary collaborations between authors.

Furthermore, the vast majority of authors hale from affluent Western institutions and countries where research money i… abun-dant. They focus on problems fac… industrialized world. Of the 9,549 … who listed their country of residen… came from either North America or western Europe. African, Asian, Latin American and Middle Eastern authors were few. Authors were mostly male: only 15.7% could be identified as female. Norms of authorship and collaboration vary, but these trends held for each year examined: female authorship remained below 17.4% and non-Western authorship under 16%, for example.

FIVE RECOMMENDATIONS

To bring in social scientists and other marginalized researchers, I have five recommendations.

First, public and private organizations should overhaul the way they structure and disburse funding for energy research and development. They should give a bigger slice to social scientists, improve incentives for interdisciplinary work and prioritize social topics in their funding calls — such as the perceptions of energy users, the needs of people affected by energy production and prevailing customs, traditions and behaviours.

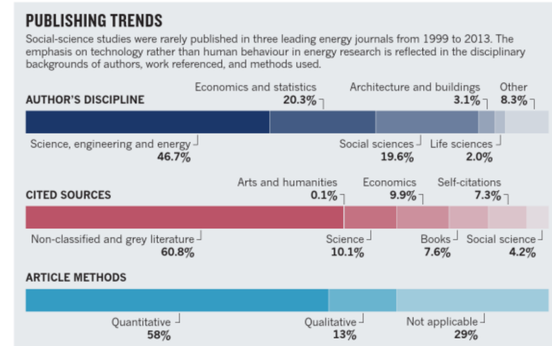
Second, to reduce disciplinary bias, energy ministries, statistical agencies and public utility commissions should focus more on energy behaviour and demand, rather than just supply. Delaware and the District of Columbia, for instance, have sustainable-energy utilities, which advise residents about behavioural changes they can make to save energy and money. The statewide energy-efficiency utility, Efficiency Vermont, provides funding and behavioural guidance to homes, farms and factories.

Third, administrators should make energy research more problem-oriented, including social perspectives as a matter of course. Universities should develop topical programmes on energy, as they have in agricultural research, medicine and business. Curricula might include efficient and sustainable consumption, risk management, public decision-making and the design of technologies for public acceptance and use. Good examples include the University of Edinburgh, UK, which offers an interdisciplinary master's degree in climate accounting; Aarhus University in Denmark has a business-development degree that combines engineering, innovation studies, energy studies, business and marketing; and Carnegie Mellon University in Pittsburgh, Pennsylvania, has an engineering and public policy department. Outside academia, the US Defense Advanced Research Projects Agency has successfully used a 'challenges-centred' approach to national-security problems since it was created in 1958.

Fourth, researchers should do more to accommodate expertise and data from laypersons, indigenous groups, community leaders and other non-conventional participants. Although this may require special training to do effectively, such interactions would encourage greater feedback and integrate diverse viewpoints.

Fifth, journal editors can prioritize interdisciplinary, inclusive, comparative, mixed-methods research. A new journal published by Elsevier, *Energy Research & Social Science* (of which I am editor-in-chief), calls explicitly in its aims and scope for papers that blend disciplinary concepts, go beyond single case studies, and utilize an assortment of methods. *Wiley Interdisciplinary Reviews: Energy and Environment* also seeks cross-disciplinary assessments of energy systems.

Energy studies must become more socially oriented, interdisciplinary and heterogeneous. Problem-focused research activities that centre on both physical and social processes, include diverse actors and mix qualitative and quantitative methods, have a better chance of achieving analytic excellence and social impact. ■



NEGLECTED TOPICS
Twelve subjects seldom considered in energy studies.

Topic	Example
Gender and identity	Pollution from cooking stoves posing greater risk to women than men
Philosophy and ethics	Future generations bearing the burden of pollution
Communication and persuasion	Energy information changing individual or firm behaviour
Geography and scale	Mismatching the size of energy systems to patterns of demand
Social psychology and behaviour	Shaping energy choices by trust, control and denial
Anthropology and culture	Temporal and regional differences in conceptions of energy services
…earch and innovation	How people, markets and institutions drive innovation
…itics and political economy	Resources contributing to conflict or stymying growth
Institutions and energy governance	Evolving rules and norms to address collective energy problems
Energy and development	Energy use contributing to economic growth and falling poverty
Externalities and pollution	Costs to society of erosions of environmental and ecological capital
Sociology of technology	Economic, political and social drivers of energy consumption

SOURCE: ADAPTED FROM REF. 5

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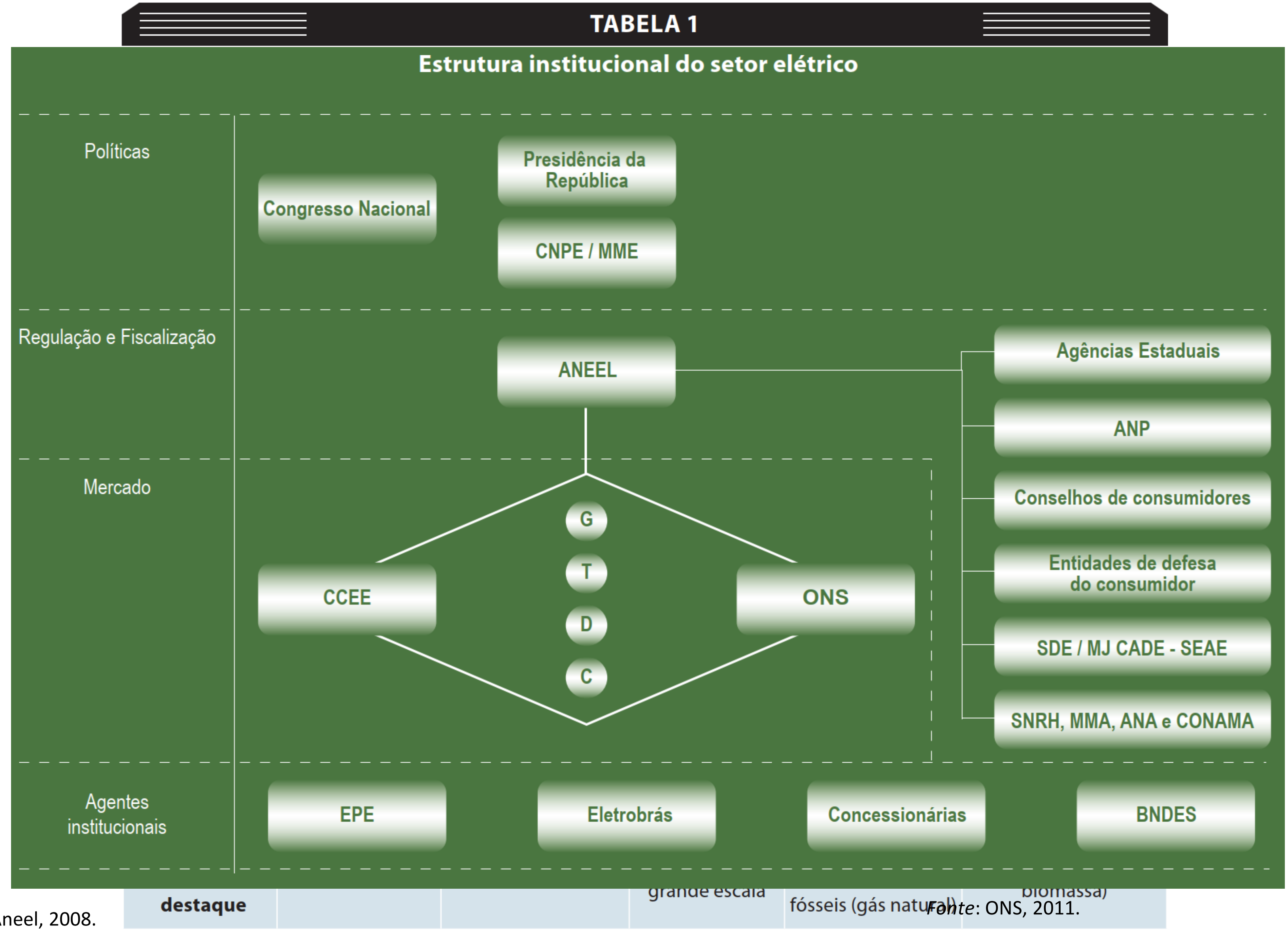
e-mail: sovacool@vt.edu

1. Dietz, T., Gardner, G.T., Gilligan, J., Stern, P. C. & Vandenbergh, M. P. *Proc. Natl Acad. Sci. USA* **106,** 18452–18456 (2009).
2. US Department of Energy *Report on the First Quadrennial Technology Review* 125 (US Department of Energy, 2011).
3. Gaffigan, M. E. *Advanced Energy Technologies: Budget Trends and Challenges for DOE's Energy R&D Program* (US Government Accountability Office, 2008).
4. Goldblatt, D. L. *et al.* (eds) *Tackling Long-Term Global Energy Problems: The Contribution of Social Science* (Springer, 2012).
5. Sovacool, B. K. *Energy Res. Soc. Sci.* **1,** 1–29 (2014).
6. D'Agostino, A. L. *et al. Energy* **36,** 508–519 (2011).
7. Lutzenhiser, L. & Shove, E. *Energy Policy* **27,** 217–227 (1999).
8. Stern, P. C. *Science* **260,** 1897–1899 (1993).
9. Alcott, H. & Mullainathan, S. *Science* **327,** 1204–1205 (2010).

Um "caso exemplar" – o setor elétrico brasileiro



Fonte: ONS, 2011.

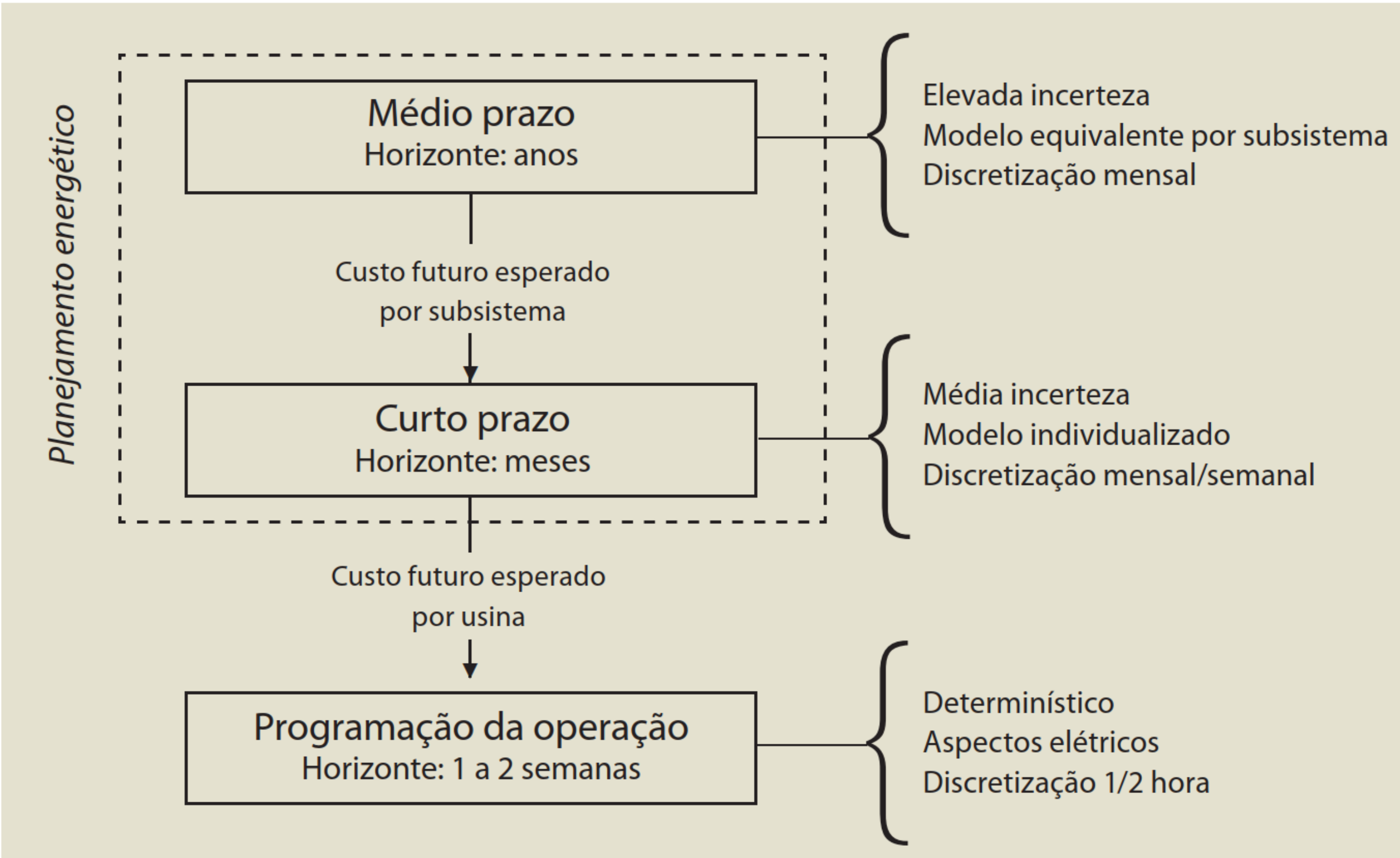
Fonte: Aneel, 2008.

Fonte: Mercedes, Rico e Pozzo, 2015.

Um “caso exemplar” – o setor elétrico brasileiro

FIGURA 3

PLANEJAMENTO ENERGÉTICO – DECOMPOSIÇÃO TEMPORAL DO PROBLEMA DE COORDENAÇÃO DA OPERAÇÃO HIDROTÉRMICA DO SISTEMA BRASILEIRO



Fonte: Zambelli, 2006

Fonte: *apud* Mercedes, Rico e Pozzo, 2015.

Um "caso exemplar" – o setor elétrico brasileiro

Marcos históricos de planejamento (expansão) na perspectiva da garantia da segurança do abastecimento

Estágio inicial – anterior à organização do setor até meados dos anos 1970

Planejamento determinístico, com base no ***período crítico***

(...) "a análise de oferta de energia era feita supondo a repetição de uma série histórica de dados em que os anos mais secos correspondiam ao período 1952-56. As usinas eram dimensionadas de forma que a geração mínima cobrisse esse período crítico, e o resultado era denominado "energia firme" (Ventura Filho, 2001, in Eletrobrás, 2001, p. 35; Eletrobrás, 2002)."

Fonte: Mercedes, Rico e Pozzo, 2015.

Um “caso exemplar” – o setor elétrico brasileiro

Estágio sob comando da Eletrobrás – de 1974 até finais dos anos 1990

Interligação dos sistemas - necessidade de substituir o critério determinístico e inserir a análise probabilística.

“Em 1977, a Eletrobrás e o Centro de Pesquisas de Energia Elétrica (Cepel) completaram um modelo de programação dinâmica estocástica (PDE) que determinava a cada mês o despacho hidrotérmico de menor custo. (...) Em lugar de considerar o pior cenário ocorrido na série histórica de vazões, agora seriam tirados alguns índices do histórico, como, por exemplo, a média, o desvio padrão e a correlação temporal das vazões medidas, e seriam introduzidos no modelo PDE, que simulava mensalmente o montante de geração térmica para obter o mínimo custo no horizonte desejado com todas as possibilidades de afluência (Kligermann, 2009; Terry et al., 1986). (...) os critérios para uso do modelo nos estudos de operação do sistema foram estabelecidos em 1979, e o modelo PDE foi usado para determinar a estratégia de operação e índices de confiabilidade nos planos de expansão (Terry et al., 1986).”

“Esse método possibilitou calcular o nível de risco no atendimento da demanda. o risco anual de déficit aceitável foi de 5%, e o planejamento da expansão e operação dos sistemas interligados passou a considerar esse risco de déficit para avaliar a disponibilidade de energia (Eletrobrás, 2002, p. 219; Eletrobrás, 2001, p. 37).”

Trabalhando com dados do mercado e da hidrologia das bacias buscava-se “assegurar o mínimo risco de desabastecimento, tanto no longo prazo (expansão), quanto no curtíssimo prazo (operação). Do planejamento provinham, ainda, os custos marginais de expansão da geração, da transmissão e da operação, que balizavam tanto a tarifação, quanto o despacho otimizado (Oliveira *et al*., 1999)”.

Fonte: Mercedes, Rico e Pozzo, 2015.

Um "caso exemplar" – o setor elétrico brasileiro

Liberalização – a primeira fase – FHC – e a segunda fase – Lula e Dilma

"(...a) Eletrobrás já desenvolvia programas de modelagem desde o final da década de 1970 e a partir das primeiras propostas metodológicas na linha da programação dinâmica dual estocástica, elaboradas ainda na década de 1980 (lopes, 2007), o Newave ganhou importância no setor no período da liberalização, mais especificamente a partir de 1999, enquanto seu complemento, o programa Decomp, passou a ser empregado a partir de 2001 (Amaral, 2003)."

"Destinado ao cálculo do custo marginal de operação do sistema, que, por sua vez, baliza o cálculo do preço a ser utilizado nas transações de curto prazo (mercado spot, no período liberalizado; de liquidação de diferenças, no presente), o preço definido a partir do uso dos programas Newave e Decomp passou a balizar praticamente todas as transações que envolvem a energia elétrica no país. Uma vez que embute o risco representado pela estocasticidade decorrente da predominância hidráulica na geração, o seu uso levou ao estabelecimento de uma forte característica especulativa (...)."

"Como critério de garantia de suprimento, a estratégia de operação do SIN considera, atualmente, como teto para o risco de ocorrência de déficit de energia (risco de déficit) o não atendimento de 5% do mercado. No período anterior à liberalização do setor, esse critério considerava inaceitável um risco superior a 5% da ocorrência de qualquer déficit (Rosa *et al*., 2000)."

Fonte: Mercedes, Rico e Pozzo, 2015.

Um "caso exemplar" – o setor elétrico brasileiro

Considerações finais

"Desde o início do planejamento brasileiro, com o grupo Canambra, até finais, com a atuação plena da Eletrobrás, de 1979, o uso do critério determinístico baseado nas séries históricas de vazões para expansão do sistema mostrou-se razoável embora gerasse incertezas, como o fato de não permitir a avaliação do risco. Em 1979, a programação dinâmica estocástica e a introdução da análise probabilística permitiram gerar mais cenários prováveis de afluência e a função do mínimo custo, inserindo também a operação com termelétricas. Porém, a avaliação do risco ficou limitada para hidraulicidades severas.

Os sistemas Baltroc e Bacus ajudaram com a implementação desses novos critérios, porém ainda deixavam as trocas entre subsistemas incipientes. A introdução da programação dinâmica dual estocástica e o Newave, em 1998, deram mais eficiência na busca da otimização econômico-financeira, mais acorde com o modelo liberal mercantil que o setor passou a ter.

Nas décadas de 1970 e 1980, a Eletrobrás gerou uma série de planos que diversificaram a representação das fontes disponíveis para geração, inclusive as usinas nucleares e os potenciais hidráulicos da bacia Amazônica foram incluídos, mas as conjunturas econômicas foram variando sua implementação.

O critério da segurança de abastecimento e, portanto, de risco também mudou, de acordo com os interesses dos atores e a configuração setorial do momento. Se antes do governo FHC tratava-se de prover socialmente o serviço, e o risco, assim como os benefícios, era compartilhado solidariamente entre os agentes, posteriormente cada um passou a buscar para si e em benefício próprio o menor prejuízo, ou a visar à arrecadação da maior parte possível do excedente."