ENERGY & ENVIRONMENTAL TRANSFORMATIONS IN A GLOBALIZING WORLD

An Interdisciplinary Dialogue

Sophia Kalantzakos | Nikolaos E. Farantouris

NOMIKI BIBLIOTHIKI

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Energy & Environmental Transformations in a Globalizing World

Editors: **Sophia Kalantzakos / Nikolaos E. Farantouris**

Abstract: This volume is a joint collaboration between New York University Abu Dhabi, and the Master Program in Energy: Strategy, Law & Economics, University of Piraeus, Greece. It explores how the world's growing energy needs and the deepening climate crisis compel scholars and policy makers to reconsider international partnerships, rethink laws and policies, re-examine institutional capabilities and search for ways to build resilience and adaptability. The purpose of this interdisciplinary dialogue is to shed light on transformations in the energy sector, institutional responses to energy security, the growing need for a diverse energy mix, city living in the Anthropocene, interdisciplinary cooperation, and the necessity for new global alliances that will provide the necessary leadership toward a low carbon future.

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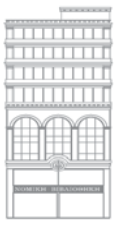

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CONTENTS

ACKNOWLEDGMENTS

We would like to thank New York University Abu Dhabi (NYUAD) for hosting the conference on *Energy Developments in a changing world - Political, economic and legal realignments* (January 2015) that led to this volume. We would also like to acknowledge Hervé Crès, Dean of Social Science at NYUAD for his encouragement and support. Special thanks go as well to the Master Program in Energy and the Research Centre of the University of Piraeus, Greece and to the Rachel Carson Center in Munich where a number of the contributors sojourned as fellows in the summer of 2015. Finally, we would like to acknowledge NYUAD Global Academic Fellows, Olga Krestyaninova and Ben Hackenberger for their assistance in the editing process.

INTRODUCTION

This volume began as a joint collaboration between scholars from New York University Abu Dhabi and the Master Program in Energy Strategy, Law & Economics, University of Piraeus, Greece. Very quickly, the collaboration widened to include scholars from Masdar, fellows of the Rachel Carson Center in Munich and expanded still further with the participation of practitioners and policy makers more generally.

The theme of this book is meant to be broad and inclusive. It explores the dynamics of change brought upon modern societies by the worsening climate crisis that forces us to look more closely at ways to move forward, build adaptability and resilience, and rethink our policies, institutions, laws and global relationships. The purpose of this interdisciplinary dialogue is to shed light on transformations in the energy sector, institutional responses to energy security, the growing need for a diverse energy mix, city living in the new era, interdisciplinary cooperation, and the necessity for new global alliances that will provide much needed leadership. The scholars and practitioners have come together from a wide variety of backgrounds and disciplines to reflect on a key series of challenges facing global society today. Readers will quickly notice a healthy range of approaches and issues. Our goal has been to reflect the complexity of the issues and demonstrate how the climate crisis is not just a question of emissions but of a holistic rethinking of the workings of today's world.

In the first section, entitled International Dynamics of Change, our contributors explored transformations and future challenges in environment and society in the Anthropocene.

Barry, Hume, Ellis and Curry discuss energy transformations as political struggles, not simply technological, market-driven policy decisions. Furthermore, they claim, energy transformations are characterised by biophysical/ecological, cultural, political economy and ethical considerations and choices. Finally, the authors posit strategies to delegitimise as well as reframe 'fossil fuels' as 'fossil resources' with multiple, better uses than burning them for energy as the key to energy transformation struggles.

Berros, a legal scholar from Argentina, brings the 'rights of nature debate' to the fore through her contribution. The particular debate has recently become more pronounced in both the ethical and the juridical fields globally. Certainly in countries of South America, the rights of 'Pachamama', Mother Earth, have been under discussion in recent years but increasingly, there are some countries where nature itself is beginning to appear as a legal entity in cases that are attracting the world's attention. The author underscores how recognition of the rights of 'Pachamama' is articulated with proposals of alternative ways of living that are intrinsically tied to indigenous peoples' worldviews and as alternatives to capitalism.

In his paper, Roukanas discusses the impact of the resource curse phenomenon on Russia, under the prism of economic nationalism of international political economy. The period that the author examines, 2001-2014, marks Putin's rise to power, the dra-

matic increase in fossil fuel prices globally, and the ongoing European dependence on energy imports from Russia. Without considerable change to its economic model, Russia will continue to be trapped by the effects of its resource abundance impacting both its own political and economic stability, but also that of the European Union. Historical political rivalries, geopolitics, economic linkages, and resource dependence on Russia all constitute an explosive cocktail for all actors involved.

In her paper, Kalantzakos seeks to move beyond the perception that the fight against climate change represents a global political failure. The author then takes a fresh look at potential new power partnerships that are more suitable to address the worsening climate crisis given the track record of the more powerful states in climate change negotiations. She asserts that a dynamic EU-China partnership can represent a more effective paradigm shift as well as a demonstration of global leadership. The leadership that EU and Chinese collaboration could provide, she maintains, may result in the necessary push to solidify a concrete vision and a roadmap to a low carbon future, allowing other developing countries to enter the fold and also, perhaps, solidifying true US commitment to the process.

Scholars from the University of Piraeus Energy Master Program lend their expertise to the second section of the book that takes a close look at Energy Developments in one of the major global powers: the European Union. Europe, the most committed and vocal proponent of a global binding treaty to curb carbon emissions, is faced with challenges of its own vis-à-vis institution building and energy management. Farantouris asserts that EU member state positions, concerning hydrocarbon exploration and exploitation continue to differ greatly and have always been fragmented. The new Article 194 TFEU while ensuring the functioning of the EU internal market, intersects with other equally important priorities, such as security of energy supply, energy efficiency, energy saving, the development of renewable sources and the optimal interconnection of energy networks. The author goes through a detailed analysis and history of the treaties and the new Article 194 TFEU to conclude that the EU still has a way to go and that the European institutional framework remains fragmented and insufficient to tackle questions of growing external reliance on fossil fuels, as well as the challenges of the hydrofracking revolution.

Farantouris' paper ties in well with the paper by Dagoumas that explores how the European policies to ensure the Triple Dividend, namely Energy Security, the completion of the Internal Energy Market, and the fight against Climate Change can be complemented by national policies. By taking a closer look at the case of Greece, he explores the complementarity between European and national polices as they seek to incorporate: the European Energy and Climate Package for 2030; enhance Energy Security through diversification of Routes and Resources and the exploitation of Indigenous Resources; implement critical energy infrastructure projects; moderate energy demand through the financing of Energy Saving projects; and incorporate the European Target Model toward an Internal Energy Market. His analysis concludes that

because of this complimentarity, Greece has the unique opportunity of becoming a significant regional energy hub in the South-East Region of the EU.

The EU's political, economic and institutional reach goes far beyond its own borders, however. In his paper, Charokopos recognizes that it is not enough for the EU to focus solely on its internal uniform Energy policy. This is why he examines the future of the Energy Community (EC) that represents Europe's most ambitious undertaking to fulfill its aspiration for integration in the energy sector beyond its borders. The EC is thus a constituent part of EU external energy policy. Can Europe fulfill its aspirations with a 'one size fits all' approach or does it need to demonstrate more reflexivity and to introduce the concept of flexibility in order to enhance the effectiveness of the EC and facilitate its further enlargement towards countries with no EU accession prospect? In his conclusion, and having taken into account the reality on the ground and the conflicting viewpoints on the future of the EC, the author stipulates that flexibility is needed and what remains to be seen is what kind of flexibility will be the most effective.

In her contribution, Loverdou goes a step further to specifically look at issues of Energy Security for the most vulnerable Member States of the EU, many of which continue to rely heavily on Russian supplies of natural gas. While the Shah Deniz Consortium's Final Investment Decision (FID) to develop the gas from the Azeri gas field in Azerbaijan, marked a milestone in EU strategy to ensure security of supply, its choice of the Trans Adriatic Pipeline (TAP), rather than of Nabucco - for the delivery of this gas to Europe- generated serious concerns for Central and South East Europe, the region meant to be the primary beneficiary of the new gas supplies.

In the third and final section, scholars and practitioners touch upon new challenges and ways to approach issues of sustainability and environmental protection in view of the worsening climate crisis.

In his contribution Sgouridis, acknowledges that our societies need to transition to a renewable energy (RE) base in about four decades to avoid the worst consequences of climate change. The rate at which we install RE capacity needs to accelerate by a factor of 30 to 50 to achieve this drastic transformation and its appropriate value depends both on how our societies choose to phase-out fossil fuels as well as on the viability of the alternative resources measured by the Energy Return on Energy Invested (EROEI). The author, furthermore, sheds light on the recurring conflict between those who believed that technology can overcome any constraint on growth and those who claimed the opposite, leading us down a path that imperils the viability of our planetary ecosystem. His paper concludes by suggesting that our societies need to transition from economies based on stocks to economies based on flows and that the Sustainable Energy Transition (SET) need not be disruptive nor uniform but tailor-made.

In his paper, prompted by Greece's ongoing recession, Paravantis focuses on the growing problem of energy poverty, basing his findings on three empirical research works on fuel poverty in Athens. His data confirms that fuel poor households are in an energy trap that is difficult to escape from and may create a fuel poverty societal gap not

unlike the digital divide. The author uses his finding to offer concrete recommendations to policy makers urging them to consider the triple injustice faced by low income households that are fuel poor, and pointed to domestic energy efficiency measures as the most promising way to close this gap.

Kaltsa, an architect and policymaker, discusses the role of cities in the Anthropocene. As resource consumers and greenhouse gas emitters, cities have an overarching impact on society and the global economy. The role of cities in the fight against the climate crisis has led to a growing discussion on the benefits of smart-cities as the world's great hope to tackle the global crisis. Because city growth continues unabated, cities are finding themselves at the very heart of the challenges and solutions resulting from the ongoing climate crisis. Worldwide, according to 2014 UN figures, 54% of the global population lives in cities, a percentage that is predicted to reach the 66% mark by 2050. Kaltsa looks at what makes cities 'smart' and presents examples of innovations primarily in Europe but globally as well. She concludes, that smart-cities are about putting together a sum of smart parts for transitioning to low-carbon societies. They draw in stakeholders, the economy, and raise questions about monitoring, the application of new technologies, e-governance, e-health and a number of other services. Ultimately, there can be no low carbon future without cities taking the transformative lead.

In their contribution Freitas, an historian, and Dias, a geologist, join forces to take a look at the challenges of coastal zone management in the era of climate change. The authors assert that linking history with other disciplines such as geology, climatology and biology, allows for a better understanding of the impacts of human activity and climate change on coastlines through a dialectical and historical perspective. The authors suggest that a more holistic view of present challenges will help both scholars and society better understand coastal systems and respond appropriately to coastal instability while helping prepare societies with the tools necessary to adapt themselves to the inevitable changes ahead.

In his paper, Kritikos takes a look at the Offshore Safety Directive adopted by the European Union as a result of numerous recent accidents linked to the ever-increasing offshore exploitation of oil and gas and explores the organizational and legal novelties that this long-awaited piece of EU legislation introduces. The author examines its added value, and how it helps to improve conditions for safe offshore exploitation of oil and gas and respond in the case of an accident. In a policy area, traditionally fragmented and 'captured' by corporate practices and ad hoc regulatory initiatives, the author seeks to discuss EU capacity to introduce common licensing rules as part of its new risk governance.

In an energy hungry world, the transition from fossil fuels to renewables also remains a challenge. The climate crisis makes the transition not only imperative but urgent. In her paper, Maltezou explores whether or not solar technologies can in fact compete with fossil fuels in Greece and the Middle East, finding promise in increasingly attrac-

tive economics that could prove to offer them as a cost-competitive alternative to conventional fossil fuels.

Kostandopoulos, an award-winning scientist, recognizes the pressing threat of climate change that requires us to diversify our energy mix and dramatically reduce our dependence on fossil fuel. In his paper, the author discusses the potential of chemically storing the inexhaustible, renewable energy of the sun into synthetic, carbon neutral, hydrocarbon fuels. His paper shows how, in this way, not only an alternative to CO2 underground storage is offered but also a solution to the problem of storing and transporting H2 which is a well-known barrier for the development of a 'Hydrogen Economy'.

In the extraordinary times we live in, it is crucial to remember that the climate crisis has many tentacles and poses continuing threats and challenges to our modern societies. While this volume touches upon a number of different areas, it represents only a small selection of problems requiring further study and policy implementation, if we are to have any hope of responding to a global crisis that will forever impact our world.

Sophia Kalantzakos & Nikolaos Farantouris

Abu Dhabi, November 9, 2015

KEY PRIORITIES FOR THE EU: ENERGY SECURITY, INTERNAL ENERGY MARKET AND CLIMATE CHANGE. THE CASE OF GREECE

Athanasios Dagoumas

Abstract

This paper explores how the European policies towards the Triple Dividend, namely ensuring Energy Security, implementing an Internal Energy Market, and tackling Climate Change can be complemented by national policies. It specifically explores this complementarity between European and Greek national policies as they seek to incorporate: the European Energy and Climate Package for 2030; enhance Energy Security through diversification of Routes and Resources and the exploitation of Indigenous Resources; implement critical energy infrastructure projects; moderate energy demand through the financing of Energy Saving projects; and incorporate the European Target Model toward an Internal Energy Market. The paper concludes that Greece can become a significant regional energy hub in the South-East Region for the following reasons: (i) key energy networks through Greece's territory can ensure higher energy security for South East and Central Europe and (ii) more efficient energy markets could lead to energy cost reductions, the exploitation of the indigenous resources in the region and the meeting of environmental targets.

Keywords: Energy security, EU triple dividend, Greece

I. Introduction

The recent ongoing conflict that unfolded between Russia and the Ukraine beginning in 2014, not long after the previous crisis of 2009, continues to rank high on the list of challenges facing European Leaders. Beyond the geopolitical, economic and humanitarian impacts, the Ukrainian crisis has once again highlighted the European Union's need to address issues of 'energy security.' Former Polish Prime Minister Donald Tusk, in fact, spearheaded the idea of an EU Energy Union[1] to achieve greater independence from Russia through the diversification of Europe's energy mix and the creation

1. Poland calls for EU energy union, EurActiv.com, April 2, 2014, viewed on July 1, 2015, <http://www.euractiv.com/sections/energy/poland-calls-eu-energy-union-301303>.

of a single body charged with purchasing gas supplies[2]. In addition, a recent report examined how the EU could diversify its energy supply to improve its energy security[3]. Furthermore, the European Commission conducted an in-depth study on European Energy Security[4] that accompanied its Communication on European Energy Security Strategy[5].

In response to the aforementioned concerns, the European Commission released its Energy Security Strategy, in May 2014. The Strategy aimed to ensure a stable and abundant supply of energy for European citizens and the economy. According to EU findings, the Union imports more than half of all the energy it consumes. One key fact that stands out in the studies undertaken by the EU is that the Union imports 53% of the energy it consumes. Specifically, its import dependency for crude oil is particularly high - almost 90%, and for natural gas 66%. To a lesser extent, EU imports of solid fuels stand at 42% and nuclear fuel at 40%. Energy security of supply concerns every Member State, although some are more vulnerable than others, such as Baltic States and the South Eastern European countries that are less integrated into the current EU energy system. The most pressing energy security of supply issue, however, remains the strong dependence on a single external supplier. Supply disruptions need not only be a product of political disputes, but they can also be caused by commercial differences or possible infrastructure failure, as well. The EU's energy dependency proved particularly problematic during the 2009 Russia-Ukraine crisis because some member states relied either exclusively or predominantly on Russian gas leaving them to face acute shortages in gas supplies in the middle of the winter.

Figure 1 represents the natural gas dependency of each EU member state from Russia. To assess the effects of a possible gas disruption on the EU, the Commission published a Communication on the short-term resilience of the European gas system and the level of preparedness for a possible disruption of supplies from the East during the fall and winter of 2014/2015[6]. Figure 2 illustrates the effect of a 6-month gas disruption from Russia in each of the EU member states. These figures clearly highlight the

2. Patrick Donahue, 'Poland's Tusk Proposes Energy Union to Break Russian Hold on Gas', *Bloomberg Business,* April 22, 2014, viewed on July 3, 2015, < http://www.bloomberg.com/news/articles/2014-04-22/poland-s-tusk-proposes-energy-union-to-break-russian-hold-on-gas >.
3. Leal-Arcas, Rafael and Alemany Rios, Juan, How Can the EU Diversify its Energy Supply to Improve its Energy Security? (January 29, 2015). Forthcoming in a special issue of the International Journal of Environmental Protection and Policy; Queen Mary School of Law Legal Studies Research Paper No. 190/2015. Available at SSRN: http://ssrn.com/abstract=2557387.
4. European Commission, SWD/2014/330, Commission Staff Working Document: In depth study of European Energy Security Strategy. https://ec.europa.eu/energy/en/topics/energy-strategy/energy-security-strategy.
5. European Commission, COM/2014/330, Communication from the Commission to the European Parliament and the Council on European Energy Security Strategy.
6. European Commission, COM/2014/654, Communication from the Commission to the European Parliament and the Council on the short term resilience of the European gas system Preparedness for a possible disruption of supplies from the East during the fall and winter of 2014/2015.

fact that specific regions in the EU, such as the Baltics, Eastern Europe and the Balkan Peninsula are vulnerable to an energy supply disruption.

Securing an uninterrupted supply of fossil fuels was not the sole policy focus of the EU. There has been a growing pre-occupation of Europeans with the climate crisis, and in fact, it is Europe that has played a leading role in international negotiations seeking to achieve a binding agreement to reduce carbon emissions worldwide. The EU has taken action within its own territory to actively promote a transition to a low carbon economy. Specifically since 2010, the European Union has been enforcing its 2020 strategy[7] by which it sought to diversify its energy mix with renewables, reduce its emissions, and promote energy efficiency.

In early 2014, the European Union also published a Communication by the Commission addressed to the European Parliament and the Council, the European Economic and Social Committee and the Committee of the Regions, on a policy framework for climate and energy policy from 2020 to 2030[8], with the goal of preparing its energy and climate targets ahead of COP 21 taking place in Paris in December 2015. In the Commission's view, the key elements of a new 2030 climate and energy framework should comprise a Greenhouse gas reduction target at EU level which is shared equitably [9]among the member states in the form of binding national targets; a reform of the Emissions Trading System; an EU level target for the share of renewable energy and a new European governance process for energy and climate policies based on member state plans for competitive, secure and sustainable energy. Energy efficiency would continue to play a significant role in delivering the Union's climate and energy goals, while it called for the establishment of a simplified but effective governance system for the delivery of climate and energy objectives.

In particular the most recent and ambitious 2030 Framework for climate and energy aims to help the EU achieve a more competitive, secure and sustainable energy system and to meet its long-term 2050 greenhouse gas reductions target. "This strategy sends a strong signal to the market, encouraging private investment in new pipelines, electricity networks, and low-carbon technology. The targets are based on a thorough economic analysis that measures how to cost-effectively achieve decarbonisation by 2050."[10]

According to this newly approved framework, achieving the 2030 targets would not incur costs that are substantially higher than those the EU would need to cover in or-

7. http://ec.europa.eu/europe2020/europe-2020-in-a-nutshell/index_en.htm, viewed on July 3, 2015.
8. European Commission COM/2014/15, Communication from the Commission to the European Parliament and the Council, the European Economic and Social Committee and the Committee of the Regions on A policy framework for climate and energy in the period from 2020 to 2030: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0015&from=EN; http://ec.europa.eu/energy/en/topics/energy-strategy/2030-energy-strategy.
9. http://europa.eu/rapid/press-release_IP-14-54_en.htm, uploaded Jan 22 2014, viewed on July 3, 2015.
10. European Commission, 2030 Energy Strategy, viewed on July 2, 2015, < http://ec.europa.eu/energy/en/topics/energy-strategy/2030-energy-strategy>.

der to replace the existing antiquated energy system. Instead, the main financial effect of decarbonisation would be to shift spending from fossil fuel resources to low-carbon technologies.

EU targets for 2030 include:

- a 40% cut in greenhouse gas emissions compared to 1990 levels
- at least a 27% share of renewable energy consumption
- at least 27% energy savings compared with the business-as-usual scenario[11]

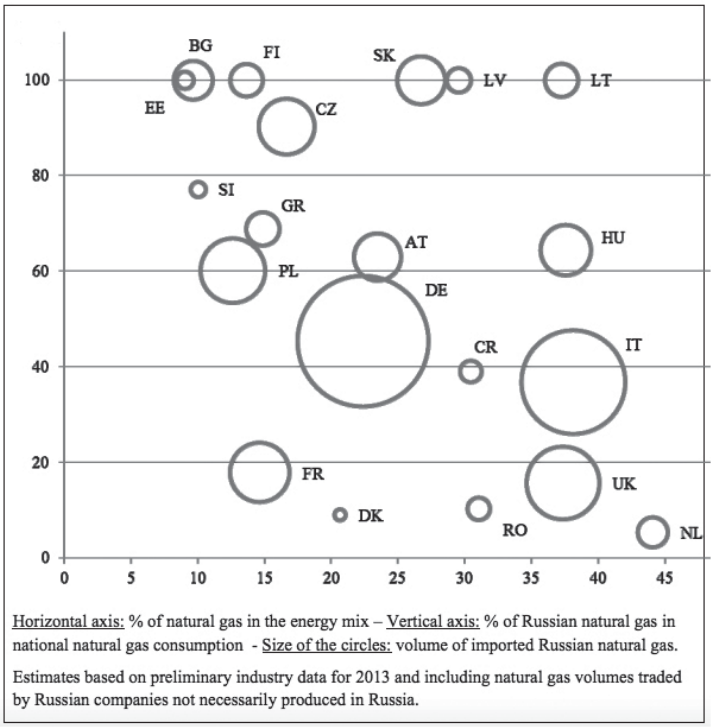

Figure 1. Gas dependency of each EU Member State from Russia, source: European Commission COM/2014/330

11. *Ibid.*

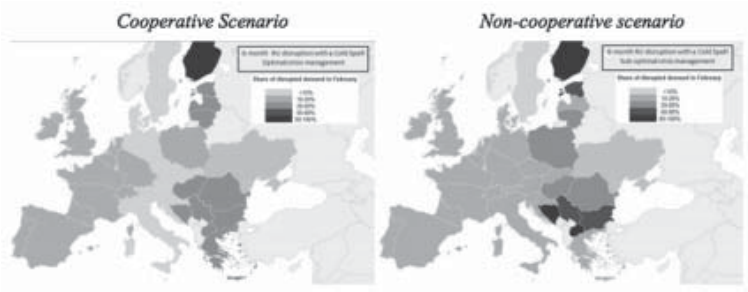

Figure 2. Maps of likely supply interruptions at the end of the 6-month Russian gas supply disruption scenario in cooperative and non-cooperative scenarios among EU Member States during a cold spell, source: ENTSOG[12] and European Commission, COM/2014/654[13]

Besides, the aforementioned communications on Energy Security and Climate Change, the European Commission has also published a Communication to the European Parliament and the Council, the European Economic and Social Committee and the Committee of the Regions on Energy prices and costs in Europe, aiming at identifying any energy inefficiencies in the European energy system[14]. The main impetus for this study has been the mounting pressure by European consumers and more particularly the industrial sector for significant energy cost reductions. The evolution of shale oil and gas in the USA, and the stricter environmental standards in the EU have raised doubts about the competitiveness of the European economy. The Commission strongly supports the completion of the internal energy market and the further development of energy infrastructure. It considers that because of EU market liberalization, industry (particularly SMEs) and household consumers can already reduce their prices by changing to better tariff regimes with existing suppliers or by switching to cheaper energy suppliers, where suppliers are sufficiently numerous. To keep energy costs in check, households and industry in Europe can improve their energy efficiency and adopt demand response and other novel energy technologies and innovations to save energy and money. More specifically for industrial competitiveness, the Commission has suggested that fiscal transfers, exemptions and reductions in taxes and levies could be a means of protecting certain industrial consumers from higher energy costs, provided they are compatible with state aid rules and internal energy market rules.

12. ENTSOG, SC GRIP 2014-2023, Southern Corridor Gas Regional Investment Plan.
13. European Commission, COM/2014/654, Communication from the Commission to the European Parliament and the Council on the short term resilience of the European gas system Preparedness for a possible disruption of supplies from the East during the fall and winter of 2014/2015.
14. European Commission COM/2014/15, Communication from the Commission to the European Parliament and the Council, the European Economic and Social Committee and the Committee of the Regions on A policy framework for climate and energy in the period from 2020 to 2030.

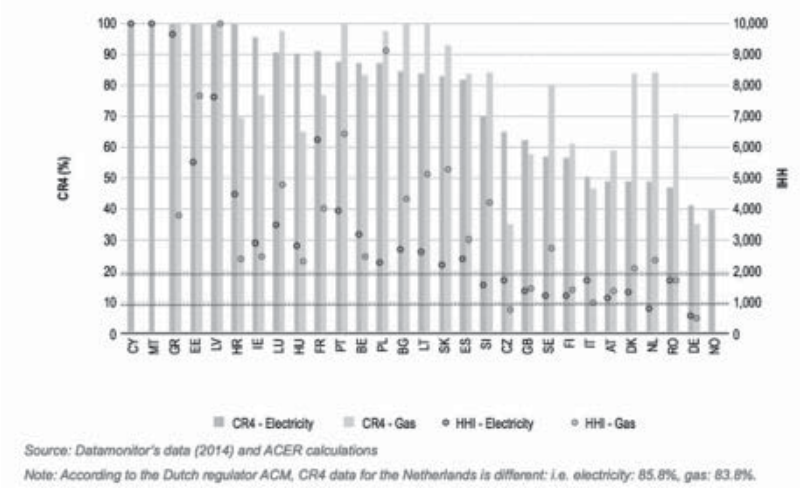

Figure 3: Concentration of electricity and gas retail markets in EU Member States in 2013, source: ACER/CEER 2014

In October 2014, The European Council, during the discussion on the Energy & Climate Package for 2030[15] agreed on the following points to: "implement critical Projects of Common Interest in the gas sector, such as the North-South corridor, the Southern Gas Corridor and the promotion of a new gas hub in Southern Europe as well as the key infrastructure projects enhancing Finland's and the Baltic States' energy security, to ensure diversification of energy suppliers and routes and ensure Market functioning." From the above analysis, as well as the Commission priority on establishing an Energy Union[16], the EU is looking to simultaneously ensure Energy Security, establish an Internal Energy Market and tackle Climate Change across the Continent. The simultaneous achievement of those Key Energy Priorities for the EU is considered a Triple Dividend, where the EU and the member states should decide a portfolio of policies that satisfy and does not offset these targets. Although these targets are considered as pan-European and the EU is designing its energy and climate strategy in order to achieve them, each Member State has its own flexibility to direct its national policies as supplementary to the European ones.

This paper will take a closer look at how Greece, a member state of the EU, has designed its policies according to the framework of the European energy and climate strategy in order to meet the Triple Dividend. Furthermore, this paper examines the complementarity of European and national policies as they are pursued in Greece. Specifically, Greece is currently forging a path toward the incorporation of the European Energy and Climate Package for 2030, while also seeking energy security enhancement through diversification of Routes and Resources and the exploitation of Indigenous Resources. Furthermore, it aims to implement critical energy infrastructure projects, moderate energy demand through the financing of Energy Saving projects,

15. European Council Conclusions of 23 and 24 October 2014, EUCO 169/14.
16. http://ec.europa.eu/priorities/energy-union/index_en.htm, viewed July 3, 2015.

FUEL POVERTY: SOCIOECONOMIC AND POLITICAL ASPECTS OF THE HUMAN DIMENSION OF THE GLOBAL RECESSION

John A. Paravantis

Abstract

This paper compiles and presents the results of three empirical research works on fuel poverty in Athens, Greece: an initial work reporting on the results of a survey of 598 households; a follow-up work focusing on the indoor environmental quality in 50 low and very low income households during the winter; and a more in-depth effort to analyze the indoor temperature measurements of these low and very low income houses. The average indoor temperature, the area and the number of rooms in the household, the number of family members, the building age and the average household income were used to cluster homes into a richer, an average and a severely handicapped poorest group. It was confirmed that fuel poor households are in an energy trap that is difficult to escape from and may create a fuel poverty societal gap not unlike the digital divide. The paper concludes with important policy considerations, urging politicians to consider the triple injustice faced by low income households that are fuel poor: although these households emit the least, they pay the most and they benefit the least from policy interventions. Energy efficiency is clearly the target future efforts should be directed at.

Key words: fuel poverty, low-income households, energy consumption, indoor temperature

I. Introduction

Achieving proper indoor temperatures in residences is necessary to protect human health, satisfy thermal comfort, and improve quality of life. Very low or very high indoor temperatures have been found to increase seasonal morbidity and mortality and constrain the social attainment of households.[1] Unfortunately, about 15 to 25% of the low-income population in Southern Europe and Ireland cannot afford to pay for heating,[2] with these figures likely to have increased significantly because of the

1. S. Bouzarovski, Energy poverty in the EU: A review of the evidence. DG Regio workshop on *Cohesion policy investing in energy efficiency in buildings*, Brussels, 2011.
2. P. Böhnke, *First European quality of life survey: Life satisfaction, happiness and sense of belonging*. European Foundation for the Improvement of Living and Working Conditions, Dublin, 2013.

worsening economic conditions globally. Fuel poverty, the inability to afford adequate warmth at home as pointed out by Paravantis and Santamouris,[3] is one of the most prominent social problems of the 21st century,[4] particularly in these times of global economic recession.

Fuel poverty affects low-income families. Its causes lie in the poor quality of the housing stock and the high cost of fuel. This paper compiles and synthesizes the results of three empirical research works on fuel poverty in Athens, Greece: an initial work reporting on the results of a large household survey;[5] a follow-up work focusing on the indoor environmental quality in a smaller number of low and very low income households during the winter;[6] and a more in-depth effort to analyze the indoor temperature measurements of these low and very low income houses.[7] The paper concludes with important policy considerations.

II. Literature review

Fuel poverty is a distinct form of inequality and one of the most eminent social problems of the 21st century. It can be quantified via the Fuel Poverty Ratio (FPR), defined as

$$\text{Fuel poverty ratio} = \frac{\text{energy consumption} \times \text{fuel price}}{\text{income}}$$

If the FPR is greater than 0.1 (10%), the household is considered to be fuel poor. It follows that poverty and fuel poverty are linked but not synonymous concepts.[8] Fuel-poor households include low-income households, vulnerable households and households with high energy bills and payment difficulties.[9] Vulnerable households contain children, elderly people and persons who are disabled or suffer from long-term illnesses.[10] Oftentimes, fuel-poor people are those who receive social security payments, work on

3. J.A. Paravantis and M. Santamouris, 'An analysis of indoor temperature measurements in low and very low income housing in Athens, Greece', Special Issue on Indoor Environmental Quality in Low Income Housing in Europe. *Advances in Building Energy Research*, Taylor and Francis, accepted for publication 2015.
4. B. Boardman, *Fuel poverty: from cold homes to affordable warmth*. London: Belhaven Press, 1991. B. Boardman, *Fixing fuel poverty: challenges and solutions*. London, Earthscan, 2010.
5. M. Santamouris et al., 'Financial crisis and energy consumption: A household survey in Greece' *Energy and Buildings*, 65, 2013, pp. 477-487.
6. M. Santamouris et al., 'Freezing the poor – indoor environmental quality in low and very low income households during the winter period in Athens' *Energy and Buildings*, 70, 2014 pp. 61-70.
7. J.A. Paravantis and M. Santamouris, 'An analysis of indoor temperature measurements in low and very low income housing in Athens, Greece', Special Issue on Indoor Environmental Quality in Low Income Housing in Europe, *Advances in Building Energy Research*, Taylor and Francis, accepted for publication, 2015.
8. B. Boardman, *Fuel poverty: from cold homes to affordable warmth*. London, Belhaven Press, 1991.
9. J. Hill, *Getting the measure of fuel poverty: Final report of the fuel poverty review*. CASE report 72, 2012.
10. B. Boardman, *Fixing fuel poverty: challenges and solutions*. London: Earthscan, 2010.
    J. Hill *Getting the measure of fuel poverty: Final report of the fuel poverty review*. CASE report 72, 2012.

a part-time basis or are in debt. Unemployment and growing job insecurity (part-time employment, short-term jobs) cause many people to live below the poverty threshold.[11]

Santamouris et al.[12] reviewed several national and international standards that define the threshold indoor temperatures required to maintain comfortable conditions in buildings.[13] Proposed indoor temperatures are between 18 and 21ºC, varying as a function of many parameters that regulate thermal comfort. The World Health Organization proposes 20ºC for the vulnerable population,[14] while 18ºC is proposed by Boardman.[15] Various medical sources propose 21ºC as a minimum temperature for the more vulnerable population and 18ºC for sedentary activities and people in good health,[16] while the WHO proposes minimum temperatures of 16ºC in bedrooms and 18ºC in living rooms for health reasons. The literature review of Santamouris et al.,[17] Santamouris et al.[18] and Paravantis and Santamouris[19] covered definitions, various issues related to fuel poverty in Greece, the EU and globally, as well as fuel poverty surveys and methods of analysis. Among their findings, only three out of the 28 EU member states have officially defined fuel poverty. Although there is no official Europe-wide definition, the comparison of fuel poverty among European countries is not trivial.

Fuel poverty is a complex socio-technical problem caused by a combination of physical, demographic and behavioral characteristics of a household.[20] Factors that have been found to drive residential energy consumption include: number of household oc-

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12. M. Santamouris et al., Freezing the poor – indoor environmental quality in low and very low income households during the winter period in Athens. *Energy and Buildings*, 70, pp. 61-70, 2014.
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18. Santamouris, M., Alevizos, S. M., Aslanoglou, L., Mantzios, D., Milonas, P., Sarelli, I., Karatasou, S., Cartalis, K. and Paravantis, J. A., Freezing the poor – indoor environmental quality in low and very low income households during the winter period in Athens. Energy and Buildings, 2014, 70, 61-70.
19. Paravantis, J. A. and Santamouris, M., An analysis of indoor temperature measurements in low and very low income housing in Athens, Greece. Special Issue on Indoor Environmental Quality in Low Income Housing in Europe of the Journal Advances in Building Energy Research, Taylor and Francis, accepted for publication, 2015.
20. Kelly, S., Do homes that are more energy efficient consume less energy? A structural equation model of the English residential sector. *Energy*, 2011, 36, 5610–5620.

cupants (very strong influence), household income (very strong correlation), building type, construction age, floor area, household heating patterns and living room temperature.[21] Most of the existing data on cold homes are from the UK, Ireland, and other northern countries where several studies have been carried out and many policies applied to improve the problem. As mentioned by Santamouris et al.,[22] most of the experimental studies carried out in Northern Europe and the UK have found that indoor temperatures in low-income houses are low and often inadequate for human comfort, with problems of internal condensation, mold and dampness found in elevated parts of buildings.[23] In some cases, very low temperatures have been found, which put the health of human beings at risk.[24]

Fuel poverty in Greece is a serious problem. Healy and Clinch[25] estimated fuel poverty in the country to vary between 24.6 and 36%. Based on the criteria proposed by

21. Department of the Environment (DOE), *English house condition survey 1991: Energy report*. London: DOE, 1996. Whyley, C. and Callender, C., *Fuel poverty in Europe: evidence from the European household panel survey*. London: Policy Studies Institute, 1997. Braun, F., Determinants of households' space heating type: A discrete choice analysis for German households. *Energy Policy*, 2010, 38, 5493–5503. EU Fuel Poverty Network, *Fuel poverty in Spain*. http://fuelpoverty.eu/2012/02/10/fuel-poverty-in-spain, accessed on 04/2013, 2012. Santamouris, M., Kapsis, K., Korres, D., Livada, I., Pavlou, C. and Assimakopoulos, M. N., On the relation between the energy and social characteristics of the residential sector. Energy and Buildings, 2007, 39, 893-905.

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25. Healy, D. and Clinch, J. P., Fuel poverty in Europe – A cross-country analysis using a new composite measurement. ESRS 02/04, Environmental Studies Research Series Working Papers, Department of

Bouzarovski,[26] the percentage of fuel poverty in Greece is near to 36%, while according to Thomson and Snell[27] it is between 16 and 17%. Eurostat[28] mentions that almost 20% of the population lives in low-income housing, while Böhnke[29] reports that almost 28% of the population lives in houses with leaking windows; it is also reported that 26% of the low-income population in Greece cannot afford to pay for heating, with a national average close to 8%. Various fuel poverty studies have classified low-income households into groups. For example, four types of households have been identified in Austria (the "overcharged", the "modest fuel poor", the "modest non-fuel poor" and those "on a low income")[30] with similar results obtained in France.[31]

Santamouris et al.[32] collected and analyzed energy consumption data for 598 households in Greece for the winters of 2010-2011 and 2011-2012. Although the latter winter was harsher, households consumed 37% less energy than expected. Cluster analysis rendered two clusters: three quarters of the households belonged to the lower-income group that lived in smaller spaces, had half the income, and consumed more specific energy (i.e. kWh per square meter) compared to the high-income group (although much less than expected based on the degree-hours of the second winter). One out of three higher-income and one out of four lower-income households adopted some conservation measures after the first winter while 2% of the higher-income and 14% of the lower-income households were below the fuel poverty threshold.

In a study focusing on 50 low- and very-low-income dwellings in Athens, Santamouris et al.[33] measured indoor temperatures and collected energy, environmental, social, and health-related data during the winter of 2012-2013. Data were grouped in five clusters based on indoor temperature characteristics. Indoor temperatures were found to be far below accepted standards, often putting the health and even the survival of the residents at risk. Energy consumption for heating was found to be much below

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33. Santamouris, M., Alevizos, S. M., Aslanoglou, L., Mantzios, D., Milonas, P., Sarelli, I., Karatasou, S., Cartalis, K. and Paravantis, J. A., Freezing the poor – indoor environmental quality in low and very low income households during the winter period in Athens. Energy and Buildings, 2014, 70, 61-70.

the country's threshold, with a high fraction of households not using heating energy at all. Finally, Paravantis and Santamouris[34] used k-means clustering to group the 50 households into three clusters (Poorest, Average and Richest) based on mean indoor temperature, surface area of the dwelling, number of rooms, family size, building age and income. They found that 7.6% of the households of the Richest Cluster, 8.6% of the Average Cluster and 11.6% of the Poorest Cluster were fuel poor with indoor temperatures registering much below accepted standards.

III. Methodology

The following research questions have been answered by the aforementioned three journal papers for the case of Greece (a rather typical Mediterranean country):

1. Which social, economic and physical/infrastructure variables are influential in grouping low-income households into homogeneous clusters? How many such clusters are formed? Do these clusters correspond to social/income classes? How do the clusters compare with one another in terms of available living space, employment status, income, household insulation, energy consumption and fuel poverty?

2. How do the measured indoor temperatures vary per month, day of the week, hour, household and cluster? How may the temperature time series be modeled as a function of time, season and the socioeconomic characteristics of the household?

Two levels of analysis were employed: 598 low income households were analyzed via questionnaires for the successive winters of 2010-2011 (among the warmest winters on record in Greece, dating back to the 19th century) and 2001-2012 (among the 15% of coldest winters on record ever); and indoor temperatures were measured in 50 low- and very-low income dwellings in Athens, Greece during the winter of 2012-2013.

IV. Results

On the results of the analysis of the 598 households,[35] a survey held in the spring and summer of 2012 collected data of the heating energy consumption for 2010-2011 and 2011-2012, from 598 households via a 2-page, 50-point questionnaire. All but the lowest income classes were found to have lost 12.7 to 31% of their 2009 income while the lowest income class gained about a fourth of its 2009 income, the distribution of which is depicted in Figure 1, likely because more household members joined the

34. Paravantis, J. A. and Santamouris, M., An analysis of indoor temperature measurements in low and very low income housing in Athens, Greece. Special Issue on Indoor Environmental Quality in Low Income Housing in Europe of the Journal *Advances in Building Energy Research*, Taylor and Francis, accepted for publication, 2015.

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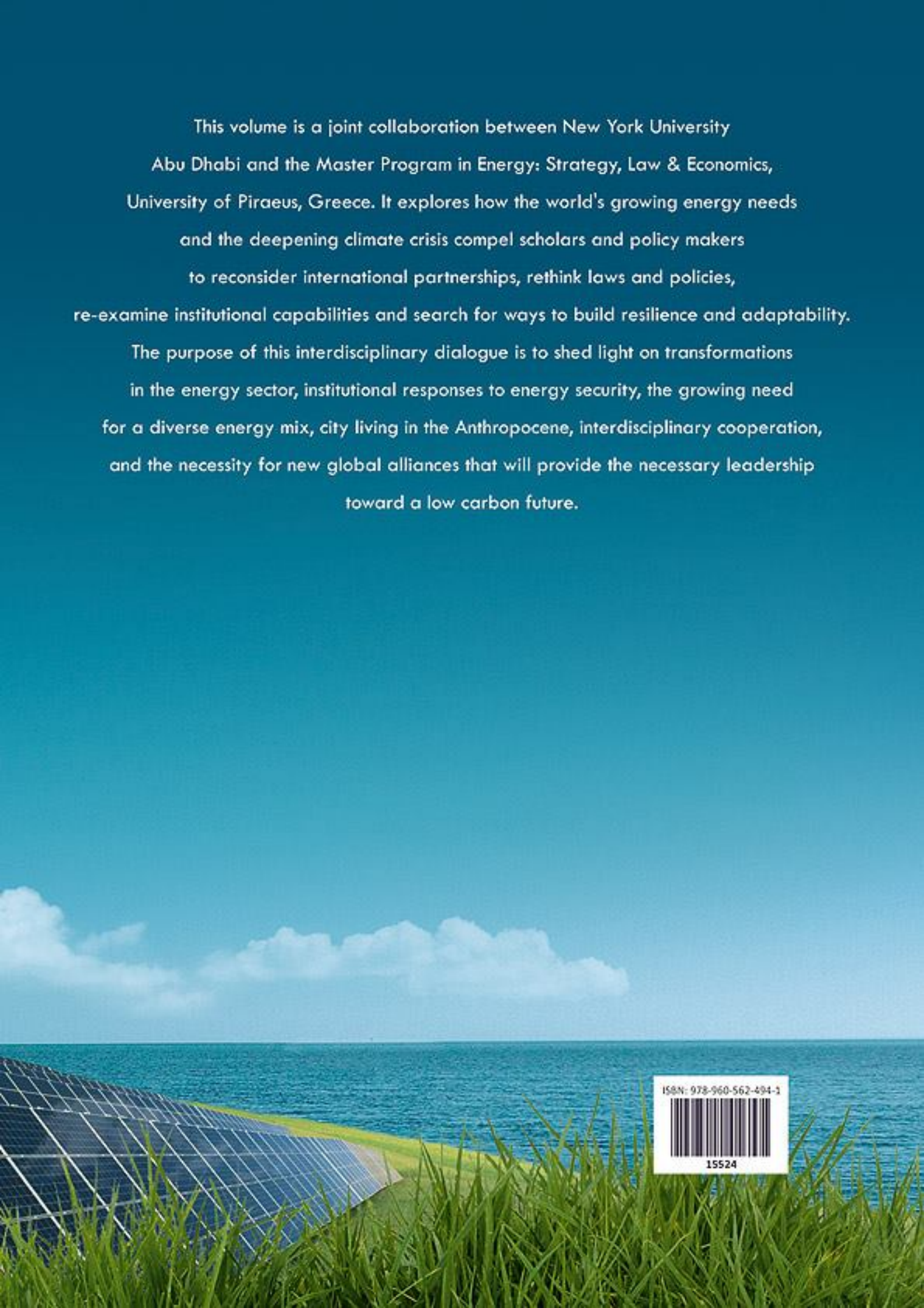
This volume is a joint collaboration between New York University Abu Dhabi and the Master Program in Energy: Strategy, Law & Economics, University of Piraeus, Greece. It explores how the world's growing energy needs and the deepening climate crisis compel scholars and policy makers to reconsider international partnerships, rethink laws and policies, re-examine institutional capabilities and search for ways to build resilience and adaptability. The purpose of this interdisciplinary dialogue is to shed light on transformations in the energy sector, institutional responses to energy security, the growing need for a diverse energy mix, city living in the Anthropocene, interdisciplinary cooperation, and the necessity for new global alliances that will provide the necessary leadership toward a low carbon future.



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