
1. Introduction¹

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This is the first ever research handbook on the energy law and policy of the European Union (EU). It is intended to be a reference work of high-quality original contributions, providing a state-of-the-art snapshot of this rapidly evolving area, situated within the broader context of international economic law and governance. The coverage of the handbook has been deliberately made as wide as possible, spanning a breathtaking variety of topics and developments in the EU's law and policies regarding energy, fully acknowledging the multi-faceted and multi-layered nature of this vast arena.

In order to make the handbook user friendly, we have divided it into four thematic parts. Part I (Chapters 2–5) deals with the *institutional* aspects of EU energy law and policy. Part II (Chapters 6–12) concerns their *external* aspects. *Economic, social and legal* aspects are covered in Part III (Chapters 13–21). Last, but not least, in Part IV (Chapters 22–28) *environmental and technological* aspects are dealt with.

Part I, on institutional aspects, contains four chapters which each deals with intricate institutional issues of EU energy law and policy.

The first question to start with, as always, is whether and to what extent the EU has a competence to act in this area. Chapter 2, by Kim Talus and Pami Aalto, answers precisely that question. It argues that energy has been at the core of the EU project since the beginning. However, only the Lisbon Treaty, which entered into force on 1 December 2009, created an explicit legal basis for EU action in this area. Article 194 of the Treaty on the Functioning of the European Union (TFEU) now provides for objectives of EU energy policy and a framework to enact EU-level regulation in this area. Talus and Aalto examine the vertical division of competences between the EU and its Member States. While the primary focus of their chapter is on the interpretation of the TFEU and its Article 194 in particular, it also discusses questions relating to multilevel governance in the context of EU energy policy.

In Chapter 3, Ries Kamphof, Thijs Bonenkamp, Joren Selleslaghs and Madeleine O. Hosli make the case that energy and climate change are salient topics in the external relations of the EU and its Member States. Both energy and climate are policy areas that fall under the scope of 'shared competences', but in their external relations dimension they generate different effects in practice. This is partly due to substance: climate action constitutes a global common goods challenge, whereas energy security is more of a national concern, largely demarcated by EU Member State sovereignty. There are also important 'trade-offs' and linkages between these two areas. Institutionally, differences exist, since there is a universal (Paris) agreement on climate change mitigation, while such an agreement is absent in the areas of global energy (security) – barring the reference in

¹ What follows draws from a compilation of the abstracts of each chapter in this Research Handbook.

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the UN's 2015 Sustainable Development Goals to the objective (SDG 7) to 'ensure access to affordable, reliable, sustainable and modern energy for all'. The authors also make the claim that future research should aim to combine the analysis of EU and Member State external action on energy and climate change, as these agendas are aligned and sometimes respective policy avenues contradict each other. Furthermore, research could focus on the effects of other actors, such as the private sector, local authorities, populist parties or major third parties, such as Russia, on the external policies, institutional framework and the global scope of action of the EU.

Chapter 4, by Leigh Hancher and Francesco Maria Salerno, analyzes competition in the context of energy policy. With three waves of internal energy market legislation already adopted and a fourth just tabled, a key question the authors pose is 'Do we have an institutional structure that can effectively deliver the ambitious goals of the EU energy and climate change policy?'. To answer this question, the chapter employs a benchmark comparison, using general EU competition law as a point of reference for an effectively enforced EU policy. It compares the current as well as the emerging institutional structure of EU energy market regulation with that of EU competition law, to assess the extent to which there is a 'competition law-ization' of energy market institutions. The authors find that the Third Package of 2009 created an institutional structure that shares a number of features with competition law, hence laying the grounds for an effective institutional structure. The new 'Winter' package, unveiled in November 2016, builds on the institutional *acquis*. However, there are also new trends – in particular a shift to relying on tools that require more EU Member State co-operation with the European Commission. This trend might limit the effectiveness of competition law-ization, unless such co-operation concerns aspects that are complementary to the core subject matter of competition law.

Chapter 5, on the European Energy Union, by Thomas Pellerin-Carlin, argues that the Energy Union is the Commission's flagship initiative for Europe's energy future. Building on existing EU energy policies, the Commission laid out its Energy Union Strategy in February 2015 to achieve the objective of moving away from an economy driven by fossil fuels, to provide a new deal for consumers, and to overcome the current fragmentation of a European energy system currently characterized by uncoordinated national policies. The author first puts the Energy Union in context and then studies it under each of its five dimensions: energy security; an integrated European energy market; energy efficiency; decarbonization; and research, innovation, and competitiveness. The chapter concludes by saying that the Energy Union project is much more than a slogan, at least in the eyes of the Commission. It then proposes fields for further research that may bring further light on the Energy Union in particular and EU energy policy in general.

Part II of this handbook (Chapters 6–12) deals with the *external aspects* of EU energy law and policy.

Chapter 6, 'The new global landscape and energy politics in the 21st century', by Klaus Segbers, makes the case that both Europe and Asia are deeply affected by major structural changes in the global landscapes. After the end of the East-West Conflict, i.e., after 1990, Europe and Asia were exposed to (but were also shaping) this new configuration. Whether these major changes will lead to a new structure or to more disorder remains to be seen. Segbers sketches the main directions of changes in the inter- and trans-national structures, and then tries to relate these changes to current energy issues. He argues that the world is undergoing deep changes, probably the most significant since 1945. A world based on

rules is possibly being replaced by something as yet unknown. There are more actors and fewer certainties. States are losing relevance, and global flows are reducing governments' role. Segbers further argues that carbon-based energy, which has been fueling global growth for decades and co-deciding the weight of nations, is both deeply embedded in the new global disorder and contributes to it.

Chapter 7, by Andrey Konoplyanik, argues that the Energy Charter Treaty (ECT; signed in 1994, entered into force in 1998) occupies an objective (economically justified) place within the evolving international energy governance system, in particular within the evolving system of investor-state investment protection mechanisms (i.e., international energy producing companies vs resource-owning host states). This system has been developing since the Middle Ages, starting from the colonies (which, from the beginning of the industrial revolution, provided security in raw materials supply for the metropolitan states), through initially territory-oriented 'traditional' concessions (from 1901), which were later modified to project-oriented 'modernized' concessions (from 1948) and risk-service contracts (from the 1960s), and which gave birth to different instruments of investment protection/stimulation in national law both in the mother countries of the energy investors and in the resource-owning sovereign host states. The growth of international trade and investment, including in energy, in the 20th century gave birth to the development of international (first bilateral, then multilateral) instruments of trade and investment protection/stimulation. Firstly, the net of bilateral instruments has evolved (first in trade, then in investment) in the case of bilateral investment treaties since 1959. The rocketing increase in their numbers due to radical changes in the political map, mostly in Europe in the 1990s, stimulated the development of multilateral trade and investment treaties as risk-mitigation instruments for international flows of energy trade and investments, mostly between West and East in Eurasia and between the dissolving USSR and the enlarging EU. The ECT has become the first multilateral treaty of its kind to secure the ongoing cross-border energy flows (with increased importance for its transit component) from the East to the West, which are to be balanced by the investment flows – at that time still to be developed – from the West to the East, to their mutual benefit.

Today the Energy Charter Treaty is still the only energy-specific multilateral instrument of international law, being a culmination of the development of investment and trade protection mechanisms in international energy. Within the EU, the ECT has been considered an external energy policy instrument of the EU. Despite the generally widespread perception that it was Russia who lost interest in the ECT (especially following the Yukos case), which culminated in the withdrawal of Russia from its provisional application of the ECT in 2009 and the accompanying statement of the Russian Government that it had no intention of ratifying the ECT, the EU has also begun to lose interest in the ECT since the adoption of the EU Second Energy Package in 2003, triggering a legal conflict between the ECT and the EU Energy acquis. This conflict has resulted in an increasing number of investor-state disputes by investors from EU Member States (all of which are ECT Contracting Parties) against EU governments and finally culminated in the withdrawal of Italy from the ECT in 2016.

Konoplyanik argues that the ECT has passed through different periods of importance in Russia-EU energy relations – from a high level in the 1990s, with a peak of mutual interest in 2002 (when the process towards finalization of the draft multilateral Transit Protocol to the ECT – which never materialized – began), to diminishing importance since

then for both parties through the 2000s, despite a growing interest in the ECT by other participants of the international energy community beyond Russia and the EU, which culminated in the signing of the International Energy Charter (additional and complementary to the European Energy Charter) in May 2015, without Russia as a Party to the Charter.

As a result of (1) the cumulative response of the global economy – on both energy demand and supply – to the oil price rises since the 1970s and the periods of high oil prices in the first half of the 1980s and from 2000 through around 2015; (2) COP-21 limitations on energy demand growth, through the establishment of an upper limit of CO₂ emissions; and (3) growing importance of the international campaign against energy poverty, there is an expected change of paradigm in international energy development (from a perceived peak supply to a peak demand vision). The dominant trends in international energy governance will most probably be changing from access to non-renewable energy resources to access to capital, financial resources and innovations, plus the minimization of negative environmental impacts from energy investments/development. The new role of the ECT, and its expanded version on the basis of the International Energy Charter and instruments to follow, might evolve.

The withdrawal of both Russia and Italy from the ECT has devalued and reformed the latter. It is worth considering this evolving set of multilateral instruments of international law not as a treaty between the West and the East, as it was treated initially, but as a North-South – or even South-South – treaty within the expanding community, mostly in developing countries who have been acceding to the ECT in recent years. This means that further development of common rules of the game for cross-border energy value chains from the current paradigm of international energy development (based on the perception of ‘peak supply’) to a new one (based on the perception of ‘peak demand’) should take place. This is why the international campaign against energy poverty and joint development of a level playing field for such international efforts might become the dominant trend and driving force behind the further evolution of the ECT and related instruments. In the view of Konoplyanik, all of this might again, on the new step of evolution of the international energy markets/economy, attract the attention of the political and business elites in both the EU and Russia to these energy-specific multilateral instruments of international law.

Chapter 8, on global energy security and EU energy policy, by Severin Fischer, makes the point that global energy security challenges have significantly changed over the course of the last decades. However, market failures remain at the heart of the problems and governments have to deal with them. This chapter concentrates on energy security challenges for the EU and on the strategies, as well as how policymakers in the EU have been dealing with oil- and gas-related supply problems. It ends with an overview of how the new concept of the ‘Energy Union’ is trying to implement a more coordinated approach.

Chapter 9, by Thijs Van de Graaf, states that the EU’s energy policy does not stand on its own, but is heavily influenced by the international political economy, that is, the shifting balance between states and markets in the world economy. The chapter begins by summarizing the key historical shifts in the global political energy economy, which provides the contextual backdrop against which the EU has attempted to develop its own energy policies and regulations. Next, it describes the key features of the EU’s traditional liberal approach to energy governance, focusing on the internal energy market, the attempts to

export those internal energy market rules to neighboring countries, and the policies to encourage decarbonization. The following section argues that the EU may be shedding some of its liberal attitudes in favor of a more mercantilist energy governance strategy. The final section concludes and raises some suggestions for future research.

Chapter 10, ‘The International Energy Charter: a new impetus for global energy governance?’ by Sijbren de Jong, reminds us that on 21 May 2015 the International Energy Charter (IECT) was signed at a ministerial conference in the Netherlands. In its set-up, the IECT aims at a wider global engagement and at balancing out the interests of energy consuming, producing and transit countries, whilst ensuring sovereign equality of states irrespective of their levels of economic development. Amidst some of the profound shifts that have taken place in international energy markets over the past decades, the IECT aims to add an additional layer of governance to the global energy landscape as, in institutional terms, the Treaty was born out of the idea that international energy markets suffer from a lack of appropriate governance. At present, an encompassing treaty or institution that is able to cover the whole spectrum of energy issues, and give a voice to all relevant stakeholders as such, does not exist. The chapter assesses the question of whether the IECT is able to fill this void.

Chapter 11, ‘The EU energy security strategy in the Caspian Sea region: addressing the bear in the room’, by Stratos Pourzitakis, argues that energy security has become a buzzword in EU politics, topping the agenda of politicians, policymakers and researchers. The chapter analyzes EU energy security strategy in relation to the Caspian Sea region. Growing dependence on Russian gas imports has become a major concern among EU institutions and most EU Member States, especially after the 2006 gas dispute between Russia and Ukraine. To this end, Brussels has been introducing a multi-faceted strategy which aims at mitigating Russian gas supply risks. In this context, the Caspian Sea region can play a pivotal role, offering alternative energy supply sources that bypass Russia. Chronic inefficiencies in the EU policymaking mechanism and diplomacy, however, hamper Brussels in its attempts to establish a realistic and effective energy security policy that will meet the current challenges vis-à-vis an evolving concept of energy security.

Chapter 12, by Slawomir Raszewski, looks at the key existing and planned gas transit projects to export natural gas from Russia and provides a critical analysis of existing conceptual debates concerning energy and the EU. Having in mind the changing global energy and climate policy landscape, the chapter first discusses the energy–environment nexus to contextualize natural gas within the emerging global climate narrative after the Paris Agreement on Climate Change of 2015. By doing so, the chapter seeks to present the ‘bigger picture’ and likely repercussions, should the emerging global climate policy become widely applied. Drawing on these macroeconomic issues, the chapter then discusses natural gas from a geopolitical angle and analyzes existing and planned natural gas projects. Having outlined the projects, the chapter draws on conceptual debates, outlining the challenges and opportunities that natural gas projects produce within the broad remit of climate change, geopolitics and development.

Part III of the Research Handbook (Chapters 13–21) deals with the *economic, social and legal aspects* of EU energy law and policy.

Chapter 13, by Costantino Grasso, shows that, as recently demonstrated by the ‘Panama Papers’ and ‘Bahamas Leaks’ scandals, corruption is rife in our societies. Quoting Kofi Annan’s opening statement to the United Nations Convention against

Corruption of 2004: 'It undermines democracy and the rule of law, leads to violations of human rights, distorts markets, erodes the quality of life and allows organized crime, terrorism and other threats to human security to flourish'.² The origins of this social plague may be traced back to the beginnings of human civilization. However, it appears that this kind of unethical behavior is particularly rampant in the energy sector. This chapter introduces the topic of corruption and analyzes the reasons behind the fact that, almost unexpectedly, over the course of the last two decades, corruption has gradually moved from the margins to the center of the international political stage. The chapter then tries to explain why, in the energy sector, such a criminal phenomenon has traditionally been so wildly rampant and its effects have proven to be extremely dramatic. Finally, the chapter offers a vivid depiction of a recent tale of dishonesty, which is emblematic of the way in which corrupt practices are commonly perpetrated within the energy industry.

Chapter 14, on electricity and gas markets, by Guy Block and Elvira Saitova, analyzes major changes in EU legislation related to electricity and gas markets. After presenting the liberalization process of the electricity and gas markets in the EU, the authors examine recent developments that aim to adapt the current market rules to new market realities and conclude by outlining the key challenges for the future.

Chapter 15, on Energy Justice, by Jan Schmitz, Kai Menzel and Fabian Dittrich, makes the case that economists agree that a tax on externalities is one of the most efficient means to internalize the social cost of environmental pollution. However, political reality in democracies has shown complications in the rate-setting exercise. Without the willingness of voters to bear their full share of the social costs through taxation, rates are nearly always too low to fully internalize even the lowest estimates of the social costs of environmental damage and climate change. Furthermore, in its currently applied versions, such a tax acts as a regressive form of taxation, since energy expenses relative to disposable income are higher for low-income households than for higher-income households.

The solution the authors propose to these two problems is straightforward: the entire revenue of energy taxation should be given back to voters. Doing so on a per capita basis, reimbursing each household with the average amount of the energy tax paid, leaves the incentive structure of the taxation setting intact. Under such a setting, the payable energy tax is higher the more energy is consumed, while, after reimbursement, the average household bears no tax burden at all. Only households with above-average energy consumption pay net energy taxes, whereas low-energy households would receive a net transfer. Energy savings continue to pay off individually, because the individual household can save energy (and enjoy lower tax payments) with the reimbursement remaining untouched. In the political realm, this should allow for much higher energy tax rates.

Chapter 16, 'Energy and the law of the sea' by Stephen Minas, states that the zonal entitlements and functional rights and obligations of the United Nations Convention on the Law of the Sea (UNCLOS) govern access to offshore energy resources and transit of energy resources via international shipping. Ongoing technological developments are deepening the nexus between the oceans and energy, placing increased pressure on the law of the sea in the management of overlapping activities and the resolution of disputes. These developments have led to increasing levels of energy-related pollution in the forms

² https://www.unodc.org/documents/brussels/UN_Convention_Against_Corruption.pdf, iii.

of oil pollution, inadequate disposal or abandonment of offshore platforms and greenhouse gases from international shipping; the deployment of marine renewable energy installations; the discovery of previously unknown resources in the Exclusive Economic Zone, continental shelf and 'Area'; and efforts to exploit the energy resources of the Arctic. In addition, energy considerations constitute a significant feature of ongoing disputes over maritime territory, such as in the Eastern Mediterranean. UNCLOS offers a robust frame for regulating these novel conditions. Minas argues that the EU has an important role to play as a policy innovator and leading contributor to the development of international oceans law.

Chapter 17, by Youseph Farah and Malakee Makhoul, argues that EU oil and gas companies occupy a significant share of the extractive industry and have a significant global reach. While this can bring benefits for communities by creating wealth and jobs, adding value and providing services, sometimes corporate activity can have an adverse effect for people and the environment. When this happens, the people whose human rights have been affected often seek reparation, and expect the company to be held to account. Victims have increasingly sought a remedy in the home state of the parent company, either in relation to its direct act or the unlawful conduct of its subsidiary in the host state. Whilst there are some isolated success stories, the evidence suggests that victims choosing court litigation within the EU, or in other home states such as the US, continue to face factual and legal challenges.

Farah and Makhoul place the debate within the EU's commitment to business and human rights. The Commission has endorsed the 'United Nations Guiding Principles on Business and Human Rights' (UNGPs) and has committed to supporting their implementation, encouraging companies to adhere to internationally recognized human rights, guidelines and principles. In relation to the oil and gas sector, the Commission issued a non-legally binding 'Oil and Gas Sector Guide on Implementing the UN Guiding Principles on Business and Human Rights', advising on how to implement the corporate responsibility to respect human rights in daily business operations. Farah and Makhoul argue that, for several reasons, the 'Oil and Gas Sector Guide on Implementing the UN Guiding Principles on Business and Human Rights' does not go far enough in improving access to a remedy. Specifically, they advocate that, due to the unique legal and business structure of oil and gas companies' engagement, it is important for those victims of business-related human rights violations in the oil and gas sector to be involved in unilaterally binding alternative dispute resolution processes to complement a state's duty to offer an effective access to a remedy for victims of business-related human rights violations, and that this may improve the effectiveness of the UNGPs.

Chapter 18, by Beatriz Huarte Melgar, argues that environmental targets for reducing emissions of greenhouse gases (GHG) is particularly relevant in the maritime sector because about 90 per cent of world trade is transported by sea, with maritime transport responsible for 2.5 per cent of total GHG emissions worldwide. In this regard, the EU, based on International Maritime Organization conventions, developed a strategy, applicable from 2013, that involves measures affecting the energy market and which aims to reduce GHG emissions within the maritime sector. It has also implemented an integrated maritime policy which covers areas as diverse as fishing, shipping and ports, and the marine environment, and has promoted the use of liquefied natural gas for ships.

Accordingly, this chapter aims to explain how the EU implements energy measures to reduce GHG emissions from the shipping sector.

Chapter 19, by Max Baumgart, argues that smart meters offer a way to address the challenges created by the growing production and availability of volatile renewable energies, but that they also create problems with respect to data protection. The implementation of interoperable smart meters on EU-law grounds creates concerns with regard to its compatibility with Article 7 of the EU Charter of Fundamental Rights. The EU should therefore adopt an area-specific protection concept, containing detailed rules to remove the concerns about the legality of interoperable smart meters. The chapter gives a detailed analysis of the smart-meter-related EU legislation and, to put the implementation of smart meters in a more general context, gives an overview of the implementation of smart meters in the United States.

Chapter 20, by Antonio Morelli, states that if it is too soon to assess the real impact of the Paris Agreement on Climate Change, it is beyond doubt that the deal adopted at the COP21 represents a landmark in the evolution of international law standards. Envisaged within Tom Franck's post-ontological framework, the analysis in this chapter illustrates how the Paris Agreement fosters shared universal standards and an effective solution in addressing universal challenges, such as climate change. The political debate as to whether the Paris Agreement consists of only words and promises or forms an effective commitment enters the legal arena in terms of a dichotomy between binding and non-binding sources of international law. The provisions of the Agreement are the result of a heterogeneous combination of both sources, which respectively come into play depending on the elements that are at stake. Through the harmonization of those instruments, it is possible to promote the universality of the standards without weighing down the rising commitment of the major stakeholders involved in solving climate change. From this perspective, the Paris Agreement combines the action of both state and non-state actors, either during the phase of negotiation or in the implementation of the deal. The contribution of those stakeholders is going to be extremely relevant in their commitment to reducing carbon emissions and energy consumption. In this context, this chapter demonstrates how the Paris Agreement, letting different sources coexist and not collide, sets the pace for the evolution of new standards in international law.

Chapter 21, by Michael Kattirtzi, argues that social science is underrepresented in the domain of energy policy. This chapter builds on social scientists' criticisms of policy construction and delivery in the UK by exploring how energy policy that was formed on the basis of social science evidence might look. Drawing on experiences in the UK but with relevance to other EU Member States, six perspectives are offered as a starting point for energy policy debates. The chapter begins with a focus on energy efficiency, considering three distinct perspectives for achieving reductions in citizens' energy demand: segmentation models; behavioral studies; and social practice theory. It then turns our attention to energy generation, focusing on what social science can tell us about policy development with regard to energy infrastructures and the placing of infrastructure projects, before discussing the sociotechnical transitions literature as a perspective through which to understand the whole energy system. The chapter concludes with some reflections on the steps that policymakers and researchers can take to ensure energy policy is better grounded in social science.

Part IV of the handbook (Chapters 22–28) deals with the *environmental and technological aspects* of EU energy law and policy.

Chapter 22, by Kati Kulovesi, explains the basic functioning of the EU Emissions Trading Scheme (ETS). It highlights challenges related to the emissions cap and oversupply of emission allowances and focuses on carbon leakage in the context of the ETS. The chapter then reviews the debate on border carbon adjustments (BCAs) in the EU over the past fifteen years, introducing and discussing recent proposals. It analyzes the impact of the Paris Agreement on Climate Change on the risk of carbon leakage in the EU, examining the extent to which this new global climate treaty can be expected to level the playing field for European industries.

The chapter proposes reforms of the ETS for the fourth trading period of 2021–2030, with a view to implementing the EU's contribution to reducing greenhouse gas emissions by at least 40 per cent from 1990 levels by 2030 under the Paris Agreement on Climate Change. Kulovesi argues that, while the Paris Agreement lays down the basic legal structures needed to step up global climate policy efforts, it is far from establishing a global carbon price and levelling the playing field for the manufacturing industry. The chapter highlights, however, that there is currently no evidence of carbon leakage having taken place as a result of the EU ETS and takes a critical stance towards proposals to strengthen carbon leakage protection under the ETS, especially by introducing BCAs. The chapter concludes that the question of carbon leakage remains relevant in the EU even after the conclusion of the Paris Agreement.

Chapter 23, 'Energy and environment', by József Feiler and Peter Vajda, departs from an assessment of the 'energy trilemma' – that is, energy security, energy equity and sustainability – and places these issues in the context of environmental economics and the internalization of external costs. It briefly touches upon the two main approaches in EU environmental law that address these concerns, namely 'command and control' measures and market-based instruments. It assesses the imperative of an energy transition and puts forward certain proposals for future research with the aim of realizing the highly needed mainstreaming of the environmental and climate topic within international energy law and policy as well as economic law and governance.

Chapter 24, by Filippos Proedrou, argues that the transition to low-carbon energy systems is the pivotal political economy issue for the EU, as it stands at the nexus of energy, politics and markets. With power markets developing into dynamic energy system integrators, smart grids emerge as the all-powerful structures that can help achieve the EU's three principal energy security goals, namely sustainability, security of supply and affordability. Smart grids integrate renewable sources at the upstream level, advance overall renewable generation, including self-generation, enable energy efficiency and conservation, and promise to achieve low-carbon security and hedge against the volatility of international energy markets.

On the other hand, smart grids call for high upfront investments and the establishment of functional markets that necessitate large-scale engagement by citizens, incentivization and education, as well as for bridging the yawning gap between textbook economics and the economy's actual workings. Moreover, while realizing that the transition to constantly balanced power loads by means of demand response management is highly promising, it may also generate a handful of adverse results. This chapter aims to critically discuss the trade-offs involved in the roll-out of smart grids and the existent barriers. In doing so,

it provides a clear overview of the current state of the art and suggests future research pathways.

Chapter 25, by Feja Lesniewska, argues that renewable energy is perceived as a primary ingredient in the world's transition to a green, clean, low-carbon sustainable economy from a brown, dirty, high-carbon unsustainable one. The global renewable energy installed capacity, especially for wind and solar power, has increased rapidly in the last decade as countries have adopted laws and policies to mitigate climate change and air pollution, as well as to improve energy security. As the sector matures, the focus on renewable energy needs to turn to considering system infrastructure design to ensure that the take-make-dispose rationale that contributed to the unsustainable fossil fuel economy is not perpetuated under the guise of a green low-carbon economy. The EU is a leader in installed solar photovoltaic (PV) and wind energy capacity. It also has a well-established waste management legal framework that is based on hierarchy and producer responsibility principles. Lesniewska considers how the EU is responding to the future challenges that waste management from end-of-life cycle solar PV panels and wind turbines pose. It questions whether steps taken to date are in line with the more advanced agenda laid out in the EU's Circular Economy Action Plan of 2015 that calls for a paradigm shift in developing law and policy which pursues holistic sustainability goals in relation to resource management throughout the value and supply chains.

Chapter 26, by Penelope Crossley, examines the complex and heterogeneous nature of the energy security challenges faced by EU Member States. It considers whether collective action at an EU level to increase the deployment of renewable energy may be a solution to these challenges. The chapter critically analyses the current state of European energy security and the history of EU interventions into the renewable energy sector. It then examines whether the recent changes to European energy law and policy are likely to solve the EU's energy security concerns by facilitating accelerated deployment of renewable energy. It concludes that, given the complex economic and political circumstances in which the EU currently finds itself, unless there are binding national targets and clear guidelines for implementing the 2030 target of 27 per cent renewable energy, it may be difficult to motivate all EU Member States to engage in collective action to accelerate their uptake of renewable energy. This could have serious implications for the energy security of the EU, with levels of import dependency predicted to rise by 2030.

Chapter 27, by David Elliott, argues that the EU faces some major energy policy choices and a need to move away from fossil fuels, with nuclear energy and renewables often being presented as solutions, but also as polar opposites; in effect defining different pathways forward. Taking a wide view, Elliott explores this polarity, asking whether these two options are indeed mutually exclusive. The chapter concludes that, although some hybrid mixes may be possible, in many ways they are technically incompatible and also reflect differing views on how society should develop. Those views will shape any specific prescriptions for energy technology research, development and deployment, although technological development and practices may influence what is deemed to be possible and desirable. Given that context, some research issues are outlined at the end of the chapter.

The last chapter, Chapter 28, by Jan Rosenow and Florian Kern, looks at EU energy innovation policy, which is key to addressing many European policy ambitions. While traditionally much of EU energy (innovation) policy had been focused on supply-side technologies, we are now seeing increasing attention paid to innovation for reducing energy

demand or increasing energy efficiency. Even though both the ambition and number of EU policies has been increasing significantly, academic analysis of the role of such EU policies for innovation and deployment of energy efficiency technologies is scarce. The authors critically discuss the ways in which EU energy efficiency policy is driving innovation and technology deployment on the basis of a review of the existing literature on the issue. First, using market transformation theory, Rosenow and Kern position the various EU policy instruments in energy innovation policy along the different stages of market transformation. Secondly, the authors identify key research challenges going forward, which include: the role of EU energy efficiency policy within a multi-level governance structure; the lack of institutionalization of EU energy efficiency policy; the need for more comprehensive policy evaluations; the importance of a better understanding real-world policy mixes; and the potential for applying a socio-technical approach to energy efficiency in the EU. The authors conclude that the lack of an explicit innovation strategy for energy demand constitutes a barrier to achieving the ambitious EU energy efficiency targets. Furthermore, the conventional understanding of market transformation is unlikely to allow for the transition at the scale and speed required to make a significant contribution to mitigating climate change across the EU.

