BOOK REVIEWS

Planetary Economics. Energy, Climate Change and the Three Domains of Sustainable Development, by Michael Grubb with Jean-Charles Hourcade and Karsten Neuhoff (Routledge:Abingdon, Oxon; New York, NY, 2016), xxvii and 520 pages, hardcover, ISBN 987-0-414-51882-6

How can economics contribute to changing our thinking about achieving global sustainability with respect to energy and climate change? The book of Grubb et al. claims that three distinct pillars of decision-making need to be reconsidered, understood and connected: behavioral / organizational economics, focusing on habits, routines and built-in assumptions governing the individual decision process; neoclassical economics which understands the individual decision process as the result of rational foresight and optimal choices leading to prices that tend to be market clearing, equilibrium constellations; and evolutionary / institutional economics which assumes that individual decisions can be rather heterogeneous, diverse, unpredictable and cumulative, implying that economic systems, in the course of their transformation, must undergo disequilibrium phases.

When I began reading this book I was keen to learn how the authors would proceed to connect the three somewhat different domains of economic theory. There is already some literature on this, where most authors discuss the intersections between behavioral and evolutionary economics. But the literature combining behavioral and evolutionary approaches, with neoclassical economics is still quite rare.[1] So the ambitious title of the book suggests that the authors would present a significant contribution to modern economic reasoning along these lines—with the empirical focus on energy and climate change.

But instead of combining the three theoretical pillars to an advanced integrated economic theory of sustainable development, the approach taken by the authors is surprisingly simple and elegant: each of the three pillars implies different political strategies towards sustainable development. In the case of behavioral economics, the authors propose political standards and their enforcement, nudges and other engagements for smarter individual choices; in the case of neoclassical economics the political approach should be based on Pigouvian taxes and greenhouse gas cap-and-trade systems; and in the case of evolutionary economics politics should focus on strategic investments for innovation and infrastructure. The book concludes that these three political domains should be combined in an additive manner, whereby different problem spheres, for example energy efficiency improvements or de-carbonization of energy supply, or different stages in economic development, imply a different balance of these three political domains.

These ideas are discussed in the first and the last part of the book. The core of the book is divided into three parts, according to the three theoretical pillars of decision making. Decision making is not discussed from the underlying theoretical economic foundations, but from the viewpoint of policies that are intended to achieve cleaner and more sustainable energy systems. The first political domain focuses on energy efficiency, the second on carbon pricing, and the third on clean energy innovations. Each of these three parts contains a rich collection of facts and figures so that the reader will learn a lot of energy policy as it is practiced: What are the successes and failures of energy-efficiency policies? What are the pros and cons of taxes versus cap-and-trade systems? How does one deal with distributional effects of carbon pricing? What are the success factors for a green innovation policy? The assessments of appropriate policies with their (co-) benefits and shortcomings are well elaborated and supported by a large number of footnotes and references, but sometimes

1. An exception, which is mentioned in the book, is Jaccard, M. et al. (2003) "Modelling the cost of climate policy: distinguishing between alternative cost definitions and long-run dynamics," *The Energy Journal* 24(1): 48–73.

a comprehensive justification according to scientific rules is missing. A shortcoming of the book is that a basic subject area of "planetary" economics is not discussed, namely the implementation of global climate agreements such as the Kyoto-Protocol of 1997 or the ambitious Paris Agreement of 2015. These international agreements are signed by fully sovereign parties so that international sanctions in the case of noncompliance are structurally impossible without destroying the spirit of the agreements.

In addition to experts and researchers, the book addresses a wider audience which is interested in global energy and climate policy. Therefore, it refrains from expositing sophisticated mathematical models, and instead focuses on the use of numerous figures, tables and explanatory boxes. However, it is my impression that the book is not entirely consistent with respect to its readership. On the one hand, readers should have some prior knowledge of energy economics because the text is full of unexplained terms and expressions that may not be familiar to non-professionals. On the other hand, experts will find a lot of material which is not really new to them. But those who work carefully through this comprehensive reader will find many challenging statements and stimulating ideas which will improve and perhaps alter their thinking about appropriate designs of energy and climate policy.

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Energy Policies of Turkey During the Erdogan Era: Facts and Lies**,** by Tugce Varol (New York: Nova Science Publishers, 2017) 264 pages. ISBN: 978-1-53610-589-6

This book presents an in depth-analysis of the general framework of Turkish energy policy since the early 2000s. Its focus is on Recep Tayyip Erdogan and Turkey's energy relations with trading partners: Russia, Azerbaijan, Iran, Iraq-Iraq Kurdistan Region, Eastern Mediterranean and Central Asian countries. The book is particularly important in order to understand the state of affairs in a region where energy is deeply politicised. The book has an explicit opposition towards Erdogan and his policies; so, it seems fair to say that the book has no claim to neutrality. The author makes this clear when she says: "The purpose of the book is to reveal the truth behind the Erdogan energy policies for more than a decade." The main research question of the study is "Did Erdogan design Turkey's energy policy for the interest of the country or for some specific companies?" and summarises Erdogan's understanding of energy policy as "construction of pipelines by companies that have connections with the Erdogan family." The main argument of the study emerges as "Erdogan and his government often developed unclear energy policies with its neighbours and some of the resulting conflicts were referred to international arbitration."

In the first chapter devoted to Russia-Turkey relations, the author says despite their similarities, Putin and Erdogan have two basic differences; first, Putin protects Russian state energy companies and helps them prosper, but Erdogan is more concerned with his party's interests; second, Putin crafts a long term strategy for Russia, but Erdogan just focuses on decreasing the natural gas bill for the next year. The author in this chapter conceptualises the general framework of Turkish-Russian relations as rivalrous, but also recognises the common need for cooperation. The chapter examines many projects realised or planned between the two countries, including pipelines, investments and nuclear energy. The core of the chapter consists of Botas' (Turkey's state-owned energy company) transfer of gas contracts to private companies for the sake of liberalisation in the natural gas market. The author's approach to the topic is holistic and includes the Syrian crisis as a parameter of Turkish-Russian energy relations. In the chapter, there are many company names and people, and the author verifies the energy business relations of these companies by revealing the personal connec-

tions of these real people. Varol emphasises that despite intense cooperation and the large volume of energy trade, Turkey could not use this as leverage for the Turkish energy companies in the Russian energy sector. The author regards this as a failure of Erdogan's energy policies.

The second chapter is about Turkey-Azerbaijan energy relations. One of the most significant findings of the chapter is that the relations between Turkey and Azerbaijan should depend upon common interests. Another finding, contrary to the popular belief, is that Turkey has not gained money from the Baku-Tbilisi-Ceyhan oil pipeline. However, the author accepts that Turkey saw this project as politically lucrative rather than economically feasible. This chapter is especially good for observing politicisation of energy in the region; it exemplifies how Azerbaijan has exploited its energy card against Turkey during the rapprochement process between Turkey and Armenia in 2009-10, for the first time in history. In terms of the TANAP project, the author is positive towards the project but she criticises Turkey for transporting its own gas via TANAP, instead of transporting through the national network at a cheaper price. Also she argues that Azeri SOCAR started to play a greater geopolitical game in order to find enough gas supply for TANAP, but this caused a decrease in Turkey's role in the project. Another key issue in the chapter is SOCAR's endeavours to buy DESFA, the natural gas transmission system operator in Greece. Varol argues that this will also be a game changer in terms of the Eastern Mediterranean. She rightly points out that Azerbaijan, as Turkey's closest ally will block the Cypriot gas to flow to Europe. The author negatively remarks that despite strategic partnerships, Turkish energy companies are not allowed into the Azeri energy sector.

The third chapter deals with one of the most complex topics of the region: Iraq and the Iraq Kurdistan Regional Government (KRG) with its capital in Erbil. The author agrees with the oft-cited thought that KRG cannot live without independent pipelines. Varol identifies some breaking points in Turkey's foreign policy towards KRG, which caused a "U turn" in regional energy relations. In 2008, Ankara, despite Turkoman/Kurdish rivalry in KRG and Baghdad's opposition, decided to develop energy trade with Erbil by importing oil by trucks. One of the reasons pushing Turkey's oil import from KRG and support of KRG independence was sanctions on Iran. The author claims that, the Turkish decision makers' plan was to constrain KRG's export options only to Turkey; in return, Ankara would not oppose an independent KRG. Starting in 2012, KRG and Turkey planned a natural gas pipeline to supply gas both to Turkey and Europe, by ignoring Baghdad. About this project, the author expresses her suspicions about the licence-owner company, Siyah Kalem, which belongs to a friend of Erdogan.

The next chapter examines Turkey-Iran energy relations. One of the important aspects of the relations, the chapter says, is a gold-for-oil system between the two countries during the sanctions. The author explains the detailed operation of this system and also gives many examples in the uneasy energy partnership of the two countries; Tehran reduced flow due to high domestic demand in winters, Ankara reduced import due to low demand in summers. A big part of the chapter is allocated to the "curious case of Reza Zarrab" and the author thinks that this network of relations is very important to understand the Turkey-Iran energy relations. Also, the author claims that examining the plans for transportation of Iranian energy to Europe via Syria is necessary to understand the root causes of the Syrian crisis. She concludes by claiming that as the western sanctions tighten, Iran becomes more dependent on Turkey.

The fifth chapter, Eastern Mediterranean (East Med), is the longest chapter; perhaps this is because the topic is the most complex energy issue globally. The chapter shows the transformation of Turkey's Cyprus policy during Erdogan-period very well. The author rightly criticises Turkey for missing the opportunity to solve the Cyprus problem when the economic crisis hit Nicosia. Another element of the chapter is Israel-Turkey relations, and Varol argues that energy projects were an influential factor for both deterioration and rapprochement in the relations. In this chapter, the author connects KRG's energy policies with Israel's energy imports and reveals interesting details of oil imports from KRG to Israel. A large part of the chapter analyses the feasibility of a Turkey-Israel

pipeline; the author has doubts about such a project with suspicions Israel is using Turkey for some geopolitical purposes.

The next chapter is about Central Asia, but unfortunately, because Turkey does not have strong relations with the Turkic countries relative to the others, this chapter does not have much to say. In the concluding chapter, Varol observes that energy decision making in Turkey has shifted away from the Ministries of Energy and Foreign Affairs towards the office of Erdogan.

Despite its high quality structure, the book is not without problems. The most important weakness of the book is its neglect of internal market dimension of the Turkish energy policy. The title of the book makes the reader guess that the book combines internal and external dimensions, yet, the book, mostly deals with the external dimensions and refers to the internal reforms occasionally. However, by far the most important energy policy of Erdogan era is liberalisation. The author might add an analysis of the transformation process from her perspective. Another weakness is poor quality of the figures; in some of them, either lines or numbers are hard to see. Lastly, the book could be more carefully edited for spelling mistakes and standardization of concepts throughout the book. To sum up, despite these insignificant editorial problems, the book is worth a read in order to observe the energy policies of Turkey during the Erdogan era.

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Taming the Sun: Innovations to Harness Solar Energy and Power the Planet, by Varun Sivaram (MIT Press, 2018) 392 pages, ISBN: 9780262037686. Hardback

In my role as an energy professor, I sometimes get versions of the question, "I want to understand if solar energy is a serious option, where do I start?" A year ago, I am not sure what I would tell them. It is easy to answer that question today. Varun Sivaram's "Taming the Sun" is a sweeping and comprehensive look at the prospects for solar energy on a global scale. It is unique in many ways, but I find most impressive its combination of deep understanding of technical possibilities, functioning of the markets in which solar competes, and the international relations at stake. It is global in scope, but takes a U.S. perspective. It is also up to date, clearly written, well-referenced, and easy to read. I had my graduate students read it as soon as I got a copy.

For someone to go this deep on a technology, one has to be at least somewhat optimistic about its potential; and clearly Sivaram is. He spent time during his PhD work at Oxford University working on arguably the most exciting advanced PV technology, perovskites. The book makes clear how big the potential for solar is. Many energy people have heard this claim in some form for the past 60 years, but Sivaram shows what many don't realize, how tantalizingly close that vision is to reality. In many places solar is the cheapest way to make electricity.

Yet the core message of this book is not that solar's time has come. Rather, it makes the case that solar faces an array of challenges that threaten its growth, including its intermittence, existing utility business models in developed countries, financing constraints in developing countries, and entrenchment of first generation PV technology worldwide. If it overcomes those challenges, it can make a tremendous contribution to global energy supply in the 21st century, alleviating many of the societal problems associated with energy production and use. If it does not, solar is likely to stumble along as a niche technology meeting less than 10 percent of global final energy demand at best. Chapter 1 provides an imaginative picture of the world three decades hence under each of these scenarios. It really could go either way.

The book documents the challenges to solar throughout, but its most intriguing economic argument is in Chapter 3, which lays out the case that solar's societal value declines as it becomes

more widely deployed. In a sense, one could make this claim about any good with a downward sloping demand curve. Unless network effects exist, consumer surplus is generally declining as technologies are adopted. But with solar, the decline is exacerbated by the opposite of a network effect. The peculiar aspects of electricity systems, with which readers of the Energy Journal are familiar, mean that intermittent sources of supply like solar will require increasing amounts of accommodation from the grid—extra transmission, backup dispatchable generation, and storage—as more solar is deployed. And because of its non-dispatchability, PV-generated electricity will undercut its own value as more PV comes online and floods the grid with power in the middle of the day. Sivaram coins the term "value deflation" to describe this effect.

Sivaram's response to value deflation, as well as the other challenges, is not to write off solar as infeasible, but to make the case that we need to double down on innovation in solar. This conception of innovation is notable in its breadth. It certainly includes technological innovation. Sivaram's time in the field, and in the lab, gives his account credibility. I would encourage anyone interested in the future of photovoltaics to closely read Chapter 6 on perovskite, organic, and quantum dot solar cells. It also includes financial innovation (Chapter 4), particularly to overcome access to capital in the places where energy demand is growing fastest, developing countries (Chapter 5). Sivaram's call for "systemic innovation" captures this wide array of changes—technical advances, as well as innovation in complementary technologies like a smarter grid (Chapter 8) and improved storage technologies (Chapter 9). Systemic innovation is needed to bring solar from a niche to a large contributor to energy supply.

Above all, he makes the case for public funding of advanced PV technology. Solar firms are investing very little in R&D, on the order of 1% of revenues. Sivaram argues that solar will need to get far cheaper to successfully overcome the array of obstacles it faces. The current generation of PV technology, based on crystalline silicon, which constitutes over 90% of world production will eventually run out of room for efficiency increases and cost reductions. We are going to hit the end of the road on the impressive improvements observed over the past several decades. We may have a few more years to run, but not enough to get to one third of electricity supply with current solar technology.

One consequence of value deflation, Sivaram argues, is that the core PV technology needs to get "dirt cheap" because all of the surrounding infrastructure needed to support it adds costs; and, due to value deflation, those costs increase as more solar is deployed. One could argue that our effort then should be to work on reducing the costs of the surrounding infrastructure rather than the core photoelectric technology, which to many seems pretty cheap already. To be fair, Sivaram's "systemic innovation" encompasses this surrounding infrastructure.

Who would argue against the notion that we should develop next generation technologies before we are desperate to use them? Some have. Sivaram is deeply skeptical about the benefits of recent U.S. administration efforts to deeply cut PV research budgets at the US Department of Energy, particularly proposals to cut and possibly eliminate the Advanced Research Projects Agency for Energy (ARPA-e).

The trickier issue is not the research in these alternatives, for which hundreds of millions of dollars of annual R&D investment would likely suffice. Rather, it is the scale-up to gigawatt and ultimately terawatt scale production of these new technologies that is what is eventually needed. Those are multi-billion-dollar bets. They raise the classic dilemma firms face between exploitation (extracting value from proven technologies) and exploration (developing new technologies that provide a recharge of innovation from which to extract value). Timing is the issue. We can fail by scaling up novel technologies too early as well as by switching over too late. Q-Cells was among the largest PV producers in the world a decade ago. Its decision to diversify beyond crystalline silicon and explore a range of alternatives was one or two decades too early and played at least some role in its demise, despite its prime position in serving the world's largest market. An argument can be made that we'd not be taking PV seriously today if we had relied more on exploration than what

actually has transpired: the relentless exploitation of cost reduction opportunities in crystallized silicon. Making PV competitive today has required every cost reduction that exploitation has been able to wring. To be sure, next generation PV will be needed. Getting the timing right on the transition from crystalline PV to alternatives will be crucial to the success of PV.

Sivaram's tone throughout "Taming the Sun" is one of realistic optimism. The progress in solar has been shocking to many. Its competitiveness has made the challenges it faces not distant concerns but immediate ones that threaten its potential to provide one of the key options that could enable a transition to a better energy system. This book provides a forward-looking pathway to address the real challenges that solar faces.

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