BOOK REVIEWS

Engineering Strategies for Greenhouse Gas Mitigation, by IAN S.F. JONES. 170 pages, (Cambridge, UK: Cambridge University Press), 170 pages, ISBN 978-0-521-51602-0, Hardback $85.00.

Climate change has ascended to a prominent position on the list of world woes. Wherever we go, many people want to talk about it and do something about it. However, for most people, the understanding of greenhouse gas emission and climate change is limited and indistinct. People appeal to governments and organizations to reduce carbon emissions, but few of us know how the problems came about and how to deal with them. This book, *Engineering Strategies for Greenhouse Gas Mitigation*, offers a panoramic view of the causes and effects of an increase in greenhouse gases and introduces possible engineering options to manage future uncertainty and control greenhouse gases.

As indicated by the title, rather than climate change policy and law, this book focuses on engineering technologies to improve energy efficiency and reduce greenhouse gas emissions including zero-emission technologies; geo-engineering the climate, ocean sequestration, land sinks and so on. Nonetheless, the book has been written without technical jargon to be accessible to a wide range of students and non-specialists who are interested in the issue.

In chapter 1, the author introduces some useful definitions and background associated with climate change and carbon emissions to give the reader a preliminary understanding of the issue. Chapter 2 looks at the concept of increasing the efficiency with which fossil fuels are used to produce work. Then the author introduces how to reduce emissions by increasing the efficiency of energy transformation, transportation and reducing heat loss from buildings. In chapter 3, the author briefly introduces a number of ways to realize zero-emission, including nuclear power, electric and hydrogen cars, renewable energy, wind power, solar power, geothermal power, hydropower, tidal power, wave power and so on.

Relative to former chapters, chapter 4 is more intriguing as it introduces a less familiar possible approach to maintaining a desirable climate without reducing the carbon emission. Geo-engineering is proposed as this alternative way. Several geo-engineering techniques are presented, such as reducing solar radiation through some sort of shading device and albedo changes or increasing reflection of solar radiation back into space through atmospheric aerosol changes. In chapter 5, the author turns to examining the issues in using the ocean as a carbon sink including cost, sequestration time and biological impact. Several ways to increase ocean sinks are introduced such as alkalinity, direct injection, and ocean nourishment. Meanwhile, correlative benefits and risks of storing carbon in the ocean are

discussed. Similarly, chapter 6 looks at approaches to use land to store carbon including carbon dioxide capture and sequestration and storage as carbonate.

Instead of modifying the climate system to maintain a desirable climate, chapter 7 looks at the possibilities of how people could adapt to climate change. Population could fall either by choice or as a result of climate change and changes in food supply. A case study of how Bangladesh could adapt to sea-level rise is presented with options of levees, moving people or accepting more flooding. Global and intergenerational equity issues are brought up as are some of the costs of adaptation and related risks.

In a brief concluding chapter, the author reviews a bit of the scientific awareness of CO_2 emissions affecting climate change, beginning with the Swede, Arrhenius in 1896 up through the formation of the Intergovernmental Panel on Climate Change in 1988 to its winning the Nobel Peace Prize with Al Gore in (2007). His following comment on the methodology of the four IPCC assessment reports, aimed at creating a scientific consensus on the science of greenhouse gases, makes one pause for thought. "The end result is documents with a non-critical style that quote peer-reviewed literature. The documents tend to quote studies that are not focused on the questions posed. Nor does the IPCC comment on assumptions that are wildly unrealistic." He mentions policies for allocating emission rights and leaves us with questions for the future relating to whether CO_2 mitigation will be adopted along with a more equitable economic system.

The book, which arose from the author's graduate course in Environmental Engineering at the University of Sydney and Sun Yat Sen University in China, can help the reader to develop a well-informed over-all opinion on the current challenges of climate change and greenhouse gas emission and engineering technologies to deal with this issue. Its forte is a rather readable and convincing description of engineering options. To this effect, the book spans a large spectrum of topics. With each topic, the author offers several exercises to help the reader to understand the topics better and a number of appendices to aid in computations. For example, in chapter 1, the author introduces how to roughly forecast the carbon concentration in the atmosphere and then gives an exercise to estimate the needed reduction of carbon emissions to the atmosphere to stabilize atmospheric carbon concentration in a specified scenario. The book contains an index and, in addition to references, a reading list for further reading.

This book is recommended to people who are interested in the issue, especially for undergraduate students and non-specialists who do not necessarily have scientific or engineering backgrounds. It also could be used as a reference or text book in an environmental engineering course as the book contains exercises and references for further reading. Could energy and climate specialists benefit from this book? The book is more appropriately used as a reference, and I would not recommend it to specialists to use as a tool book in their research since most of the chapters are not so involved in technical details. Even though, I believe the book is able to inspire experts with new research ideas by giving an overview of neighboring disciplines. However, the simplification does not hinder

the fact that each topic treated brings rich information on engineering issues related to greenhouse gas emission and climate change.

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Energy 2050: Making the Transition to a Secure Low Carbon Energy System, edited by Jim Skea, Paul Ekins, and Mark Winskel, (UK: Routledge, 2010). 408 pages, Hardcover, ISBN 978-1-84971-084-8.

This book provides a detailed analysis of UK low carbon energy futures from a five-year programme of research by the UK Energy Research Centre from 2004 to 2009. The research reflects the strengthening commitment over this period of the UK Government to achieve a rapid decarbonisation of UK energy systems, whilst maintaining security of supply and affordability of energy services to domestic and commercial consumers. After the Introduction, Chapter 2 examines current UK energy system trends, technology options and environmental impacts. Chapter 3 then charts the development of UK energy policy and institutions, leading to the passing of the Climate Change Act in 2008, which set a target of reducing the UK's greenhouse gas emissions by 80% by 2050 from 1990 levels, and put in place an institutional framework for setting five-yearly carbon budgets to ensure that the UK is on track to meet this long-term target. Chapter 4 sets out the framework used in the research to explore energy futures, around four core scenarios—a reference scenario, a low carbon scenario to meet the 80% target by 2050, a resilient scenario targeting the maintenance of energy service delivery in the face of shocks and stresses, and a low carbon resilient scenario that combines the features of the latter two.

The strength (and weakness) of the approach is that it based on a UK version of a large-scale, technology-rich energy system model, MARKAL, supplemented by two other models for electricity generation (WASP) and gas and electricity infrastructure (CGEN). MARKAL enables a wide range of technology options on the supply and demand-side for energy generation and conversion to be modelled. The elastic demand version used, MARKAL-MED, maximises the sum of producer surplus and consumer surplus, as a proxy for social welfare. Given a profile for energy service demands to 2050, based on 2% annual GDP growth, moderately increasing world energy prices (oil reaches $70/bbl by 2050) and 10% market discount rates, this enables the model to find the socially optimal mix of technological options to meet this demand, given the constraints imposed in any particular scenario. Hence, the model will always find a solution, and the analytical content comes from the detailed characteristics of the solution found, together with the scenario and sensitivity analysis undertaken. A range of sce-

narios are explored, for example seven low carbon scenarios with different emission reduction targets, early or late action and market or social discount rates. Unfortunately, this produces a large range of outputs that somewhat obscures the findings of the core scenarios. The core low carbon scenario reaches the 80% GHG emission reduction target by first decarbonising the UK electricity system, with significant contributions from coal with carbon capture and storage, and later new nuclear power stations, and then increasingly using low-carbon electricity for heating and transport applications. This requires the marginal price of CO_2 emissions to rise to £100/t CO_2 in 2035 and over £150/t CO_2 by 2050 (in £(2000)).

The resilience of energy systems is investigated by analysing the response of the system to external shocks, using a range of micro and macro indicators. This suggests that reducing energy demand through enhanced efficiency measures is the key to a resilient energy system. However, the analysis suggests that this would lead to high social welfare losses. This is clearly an area where further research is needed, in order to investigate in more detail the value that domestic and industrial consumers put on reducing their energy demand as compared to the value they assign to any loss of electricity supply, for example. This will be crucial as the industry moves to actively managing supply and demand through smarter electricity grids. Further chapters and associated scenarios examine accelerated technology development, microgeneration, lifestyles changes to reduce energy demand, other environmental impacts and sensitivity analysis to changes in oil and carbon prices.

Overall, the book contains a wealth of detailed and thoughtful analysis that will be useful to energy policy-makers, scholars and analysts. The scenarios demonstrate the scale and complexity of the challenge in moving to low carbon, resilient energy systems. More could have been done to guide the reader through this mass of detail, for example, by using summary boxes for the main points at the start of each chapter. Nevertheless, I would recommend the book as a useful guide for serious analysts of a low carbon and resilient energy future.

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Post-Kyoto International Climate Policy: Implementing Architectures for Agreement, edited by JOSEPH E. ALDY and ROBERT N. STAVINS (Cambridge University Press: New York, USA, 2009), 1022 pages, ISBN 978-0-521-12952-7 paperback, List Price $73.00.

This edited book arose out of research from the Harvard Project on International Climate Agreements. Fifty four prominent experts from Australia, China, Europe, Japan, India, and the United States with assorted backgrounds including economics, law, political science, business, international

relations and natural science contributed. The stated goal of this ambitious project and this related edited volume is to "help identify the key design elements of a scientifically sound, economically rational, and politically pragmatic post-2012 international policy architecture for addressing the threat of climate change."

Timothy Wirth, former Representative and Senator from Colorado and President of the United Nations Foundation, sets the tone for the volume in a forward laying out some of the perplexing issues to this global problem: scientists increasingly strident calls that something needs to be done and soon, determining whose to blame, whose to gain, whose to pay and how, bringing in the biggest emitters—the U.S. and China, and designing an agreement deemed fair enough for all to sign and enforce.

The editors begin with the strengths and weaknesses of the 1997 Kyoto agreement. Its strengths were built in flexibility with emissions trading, joint implementation (JI), whereby developed countries which have agreed to reduce emissions (Annex II countries) could get credit for approved carbon reduction projects in other Annex II countries, and the clean development mechanism (CDM), whereby Annex II countries could get credit for projects in developing countries. In addition countries are allowed to meet targets in their own way. Kyoto was perceived to be fair enough with the rich paying that it became politically viable with more than 180 signatories. Its failures include the non-ratification by the U.S., the large number of rapidly emerging markets that will soon pass the rich countries in emissions, the small numbers reducing emissions inviting trade leakage, its short duration, and weak incentives for compliance. In addition there is the lack of a will or a way for some developing countries to properly implement CDM to make emission reductions verifiable, additional (reductions that would not have otherwise taken place), and permanent. The architectures discussed in the book often try to build upon these strengths while addressing the weaknesses.

The editors divide potential policies into three groups: a. targets and timetables, b. harmonized national policies, and c. coordinated and unilateral national policies. Emissions targets and timetables by country would be designed to bring all countries in over time, perhaps based on formulas. Harmonized domestic policies could include uniform taxes or cap and trade to reduce costs and generate revenue to implement policies. The most decentralized would be each country deciding what policies to implement yet with some coordination with others.

The editors first summarize the book around 5 issues and initiatives called for in the Bali (2007) meeting with an additional one of their own: 1. a long-term global climate policy goal, 2. emission mitigation, 3. adaptation to climate change, 4. technology transfer, 5. financing the policies and 6. equity. They then discuss the book chapter by chapter within the 7 sections of the book.

There are seven chapters in the section on alternative international policy architectures. The majority focus on market based policy approaches.

In Chapter 2, Jeffrey Frankel of Harvard University proposes targets for all countries by formulas and even develops such targets to 2100 for eleven world regions. He bases his formulas on a number of premises including that the U.S. will not buy in if developing countries don't and that China and other developing countries will not buy in if the U.S. does not and if they perceive the relative sacrifices made are unfair.

In Chapter 3, Denny Ellerman of the Massachusetts Institute of Technology suggests that the European Union Emission Trading Scheme (EU ETS), though imperfect, can serve as a springboard for developing a broader global policy. He considers its pros and cons as a global architecture and as with Frankel he conjectures that harmonization and participation will be issues to contend with. In Chapter 4, Judson Jaffe of Analysis Group and Robert Stavins of Harvard further the discussion with tradeable permits that are initiated at a local rather than a global level as is already occurring in the European Union, Norway and New Zealand, among others as well as having been considered elsewhere. Such programs can be directly linked through permit trading across markets or indirectly through credits for carbon offsets. They consider the various types of linkage and their implications.

Many oppose cap and trade with offsets as a recipe for corruption and political manipulation. Their price variation will increase risk and there is the seemingly inability to negotiate and enforce the necessary global limits. Thus, in Chapter 5, Richard Cooper of Harvard proposes a world-wide tax on emissions of GHGs from all sources. He suggests the broadest possible geographical coverage that includes as many greenhouse gases as feasible as well as changes in forests sequestration. Such a policy avoids the political pitfalls of cap and trade with offsets and fits into existing institutions. Countervailing tariffs could be used to encourage participation and enforcement.

In Chapter 6, Ramgopal Agarwala of Research and Information System for Developing Countries in New Delhi, India considers differences in perspective between developed and developing countries. He argues that each side must acknowledge what he calls inconvenient truths. The rich must accept historical responsibility and recognize the non-acceptability of alternative life styles for rich and poor. The poor must do more research to be convinced of the cost of climate change to them and not hide behind their poor. They must acknowledge that their rising middle classes are also part of the problem. He also argues for the need to convince populations of the short term need to act. He criticizes the failings of Kyoto and discusses criteria necessary for a global agreement. Such an agreement should be comprehensive, equitable, efficient, and implementable though international organizations with realistic emission targets. In the shorter term, getting the price of carbon right is essential, in the longer term technology development and dissemination are likely to play a predominant role.

In Chapter 7, Akihiro Sawa of the University of Tokyo considers sectoral approaches to carbon mitigation. He notes and discusses their poten-

tial advantages include participation of more countries and relief from cross country competitive issues. With smaller negotiating parties and less cost uncertainty gaining a consensus may be easier. Sectoral approaches may promote technology development and transfer and cost savings within the sector. They may, however, be difficult to negotiate in an international framework aimed at the nation level. He notes they will have other disadvantages as well. They will not necessarily be effective from an overall standpoint of reducing emissions at the lowest cost, they may require more information and government intervention and they may potentially clash with anti-trust laws. He also outlines potential sectors and architectures along with incentives for such agreements.

In Chapter 8, Scott Barrett of Columbia University furthers the arguments for a sectoral approach by considering a portfolio of sectoral options that are separately negotiated but linked. They could include not only mitigation but adaptation, technology development, reforestation and even geoengineering of the climate. He feels that a portfolio approach will reduce risk. He argues sectoral agreements of indefinite length will avoid the short term nature of the Kyoto Protocol and will be easier to negotiate and enforce citing other sectoral agreements as examples.

Part II of the book contains 4 papers dealing with negotiation, assessment, and compliance.

In Chapter 9, Bard Harstad of Northwestern University argues that having rules for negotiating treaties and their updates can promote less strategic behavior and more efficient agreements. The five rules he discusses are: (1) to harmonize or allocate country contributions by formula, (2) to have a long time horizon for the treaty, (3) to have an ambitious default outcome that becomes binding if the negotiations fail, (4) to not require unanimity amendments, and (5) to have a minimum participation requirement before the treaty is binding. Entry can be encouraged under the above rules and exit discouraged if the treaty is bundled with trade agreements for low carbon technology and R&D subsidized internationally.

In Chapter 10, Carolyn Fischer and Richard Morgenstern of Resources for the Future consider various metrics for measuring countries activities to comply with treaty obligations or to voluntarily lower carbon emissions. Issues of fairness, integrity, credibility and effectiveness are all considered. They note that most nations are taking some action relating to greenhouse gas mitigation including carbon pricing, subsidies to low emitting technologies, efficiency standards for vehicles, buildings, equipment, and appliances, product labels, R&D, and foreign aid. The diversity of policies and circumstances makes it difficult to come up with one metric that fits all. Their suggested metrics include emission targets, emissions reductions, total costs of mitigation efforts, and marginal costs. They outline current reporting requirements for the Kyoto Protocol's Annex I countries and conclude that more than one metric will be needed to measure progress.

In Chapter 11, Eric Posner of the University of Chicago and Cass Sunstein of Harvard University focus on justice in the allocation of cost burdens in a cap and trade system. They concede that a per capita allocation is more just or equitable than an allocation based on existing emissions or for equal permits for each nation. However, they outline a number of flaws that can be considered in such an allocation. It may not be politically feasible, countries with large populations aren't necessarily poor, it might encourage population growth, it does not take into account the cost of mitigation in particular countries nor its benefits. Further to the extent that poor countries are ruled by elites that may appropriate the benefits of the allocation, the rewards may not even go to the poor after all. Thus, they suggest consideration of an approach that aims to be more progressive and which will truly favor the poor in its allocations.

Many authors have alluded to the failure of the Kyoto Protocol to achieve sufficient participation and to enforce compliance. This is hardly surprising given that the costs of climate change may be felt disproportionately by poor countries with weak governments, while the costs of mitigations are expected to fall disproportionately on industrial countries that account for much of the current CO_2 build-up. In Chapter 12, Robert Keohane of Princeton University and Kal Raustiala of the University of California at Los Angeles consider political issues in obtaining a successful agreement in such a situation that will have sufficient participation, rules that will mitigate the carbon build-up, and mechanisms to enforce compliance. They argue that cap and trade is the only mechanism that can garner enough political support. They make a case for buyer liability for permits as a mechanism to ensure enforcement. Thus, markets could discount permits from jurisdictions where permits might be of dubious quality or where sellers obstruct assessment.

There is little dispute that technology will play a key role in dealing with climate change. The three papers in Part III of the volume consider the role and transfer of technology. In Chapter 13, Richard Newell of Duke University lays out the magnitude of the commitment to switch from using fossil fuels for 80 % of our global energy needs to more benign sources in terms of carbon intensities including energy efficiency, renewable energy, nuclear power, and carbon capture and sequestration. The change is thought to require investment of more than a trillion dollars a year for the foreseeable future. He puts forward the standard economic arguments that the most effective ways of spurring the private market to make the proper investment in GHG mitigation are long term agreements that put prices on such emissions. The public good nature of information also suggests that the market will under invest leaving a role for government support, particularly for basic research that the private sector is unlikely to commit to. The two current primary means for technology transfer are international trade and international development aid. He argues trade should be enhanced through reducing barriers, increasing credit availability, increasing international aid, increasing international co-

operation in R&D, protection of intellectual property rights with funds to purchase and disseminate those rights.

In Chapter 14, Andrew Keeler and Alexander Thompson of Ohio State University suggest that a way to get buy-in for developing countries is through a larger but more relaxed offset program than the CDM, which allows Annex II countries to gain carbon credits through approved carbon reducing activities in developing countries. A more relaxed program could better fit the developed countries' need to buy more offsets, while transferring more funds and technology to developing countries, whose most immediate concern is economic development. International negotiations and institutions could focus on ways to improve offset programs by lowering transaction costs and improving their effectiveness.

In Chapter 15, Fei Teng, Wenying Chen, and Jiankun He of Tsinghua University in Beijing also support an enhanced CDM focusing not only on credit for reduced emissions by project but for governments to be given offset credits for implementing policies and programs that lead to emissions reductions and sustainable development. Sectoral programs could set baseline emissions and companies below those levels could receive carbon credits. The authors argue that broadening CDM in such appropriate ways could reduce transaction costs and stimulate the development and transfer of new low carbon technologies.

Carbon policy is intimately linked to trade. If local policies price carbon, there may be leakage to other parts of the world which have no price on carbon. Or there may be a race to the bottom as industries relocate to places with the least stringent environmental regulations. Thus, some governments hoping to make their economies more competitive may be loath to pass very restrictive environmental regulations.

Countervailing tariffs may be used but some fear they may run up against trade policy regulations. Also heterogeneous environmental rules can make trade more difficult as well. In Chapter 16, Jeffrey Frankel of Harvard University considers such trade-offs and conflicts between environmental and free trade policy and argues they are not necessarily incompatible. He believes it is likely that carbon intensive goods will be the subject of tariffs and other restrictions when they come from countries with low or no carbon restriction commitments. Such restrictions may also be protectionist with the environmental issue used a pretext as is sometimes the case for dumping and other charges in WTO disputes. However, he argues the WTO has provisions to deal with such disputes, allows for protection on environmental grounds, and has ruled in favor of such protectionism in a number of landmark cases. He further argues that the environmental Kuznets curve suggests that with trade and development the will and means to improve the environment will increase. He concludes with an inappropriate black list of trade policies for promoting environmental goals and a more appropriate white list that would not run up against WTO rules but would deal with issues of leakage and competitiveness.

As is generally acknowledged and as many of the chapters reiterate, carbon emission reduction will require the participation of more than the industrial countries. Many of the chapters mention trade policy as a means of encouraging participation in carbon reduction agreements and in enforcement of the commitments. In Chapter 17, Larry Karp of the University of California at Berkeley and Jinhua Zhao of Michigan State University lay out a design for a successor Kyoto agreement. Key features include mandatory country specific targets that will be phased in over time for developing countries, which include escape clauses with penalties if compliance is unusually costly. WTO trade consistent sanctions could fit into this framework to encourage compliance or participation by non-signatory nations.

Part V of the book has five papers that deal with the thorny issues relating climate policy to economic development, adaptation, and deforestation. As already alluded to, trade-offs between environmental goals and development are key issues in enticing the developing countries to participate in climate policy, as are tradeoffs between efficiency and equity. In Chapter 18, Jing Cao of Tsinghua University in China suggests a long-term four stage policy to deal with participation, efficiency, and equity. Developed countries should commit to tighter controls now, reflecting their historical responsibility, while developing countries should commit now to later reductions that become increasingly stringent until the 4th stage when everyone has binding targets enforced with strict penalties. The losses from climate change, now thought to be larger for developing than developed countries, along with expansion of the clean development mechanism and financial and technology flows would be incentives for participation of developing countries. She suggests an organizational structure for an agreement including a global climate agency, regional groups (clubs) of countries, and individual countries along with metrics for burden sharing developed from historical responsibility including carbon sinks, capacity to pay, and per capita rights to emit. Adaptation costs, if available could also be included in burden sharing formulas. She also includes a discussion of the Chinese situation with some potential costs of climate change along with some renewable energy projects and policies.

In Chapter 19, E. Somanathan of the Indian Statistical Institute in New Delhi offers more insight on the development—environmental trade-off from an Indian point. He recognizes the need for developing countries to join in to solve climate change problems, but he is pragmatic in noting that poor countries are not yet prepared to sacrifice very much development for a problem that many in their population feel they did not cause. Nor do many of their citizens understand the serious consequences that may fall upon them if emissions are not mitigated or they are unable to adapt to environmental consequences. Even the richer countries have not displayed a willingness to reduce emissions by the required amounts. His conclusion is that technological change is the only politically feasible solution to the problem. Therefore policies should be strongly focused on technology development and transfer.

Cap and trade may play a role but caps must be made tighter in rich countries, lower income countries have to take some risks to commit to reducing emissions below their business as usual case to generate credits under a high degree of uncertainty, and profits to poor countries have to generate enough cash to pay for implementation along with a return on their investment. Further, the developing countries involved will need the requisite institutional capacity to comply with committed permits. He notes vulnerabilities amongst the very poor in developing countries including increasing fuel cost and movements back towards non-commercial fuels with increasing carbon prices. Such a movement can increase indoor pollution along with increased particulate matter and deforestation, both of which also have feedback effects on the climate. These vulnerabilities from carbon trading cause him to urge policy makers in rich countries to focus much more of their efforts on developing markets for carbon neutral technologies. Spending more money on R&D in these countries is likely to receive more political support and the results will subsequently be transferred to those in the developing world. Labeling and standards may help dissemination of improvements in technical efficiency. He urges development of an international body that could do R&D and disseminate information on climate related issues including sustainable urban transport systems, agricultural adaptation to climate change, and reduction of agricultural emissions of GHGs. He cites the Green Revolution institutions as a possible model for technology and proof positive that dramatic technological transfers are indeed possible.

In Chapter 20, David Victor of Stanford University, carries on the theme that growth is likely to trump the climate in the developing world and that their governments likely lack the ability to implement climate policies. However, he suggests a somewhat more intriguing solution. Rather than global agreements, the climate accession deals (CAD) should be negotiated with individual developing countries. That way each agreement could be tailored to solve local problems in a way that is as favorable as possible to climate goals. Developing countries could put in bids for projects to support. Industrial countries would choose and provide financial, administrative and other support for the project. Because these deals are better aligned with local needs, they may be more stable and enforceable. He cites a number of potential deals including improving efficiency in Chinese and Indian power plants, reducing forest fires in Indonesia, and carbon storage and sequestration in Saudi Arabia. He concludes with a discussion of administrative problems and solutions and suggestions of other international agreements such as the WTO and IMF that could serve as models.

In Chapter 21, Daniel Hall of Resources for the Future, Michael Levi of the Council on Foreign Relations, William Pizer, now with the Duke University, and Takahiro Ueno of the Central Research Institute of the Electric Power Industry in Tokyo carry on the discussion of how to engage developing countries in a climate agreement. They first make an argument for eliminating

fuel subsidies in developing countries perhaps in exchange for financing and technical assistance. They next discuss bringing energy efficiency levels up to world class levels perhaps through labeling, government procurement, or standards. Again financing technical assistance in addition to regional partnerships may be useful. They also consider technology diffusion which could be encouraged through technology funds, capacity building for intellectual property rights, and various financial guarantees. They consider criticisms of offset programs such as the clean development mechanism and make suggestions for changing or enhancing them with policy, program, and sectoral agreements. They further argue that no matter how CDM is reformed there will still be a need for more funds than are available. They suggest a variety of policies to supplement existing programs including international technology funds, diplomatic efforts, financial penalties, support for adaptation, and they also consider institutions to negotiate and enforce such agreements.

Since deforestation is thought to contribute up to a quarter of all current GHG emissions and existing forests are estimated to be sequestering more than 50 years of carbon at current emission levels, forest management should be an important element in any future climate agreements. In Chapter 22, Andrew Planting of Oregon State University and Kenneth Richards of Indiana University hold this view and begin by considering the failings of the Kyoto Protocol with regard to forest management. Their suggestions are based on the premise that a large range of countries will have treaty obligations to reduce carbon emissions. They note different kinds of terrestrial sequestration including forests, crops, and grazing lands and management practices that might reduce loss of sequestered carbon or increase sequestration. They focus on a forest management agreement and suggest issues that will need to be addressed such as the unit of analysis from individual projects up to national inventories, how the policy is linked to the overall agreement, determining a base line from which to measure forest inventories, whether that baseline is a stock or flow, and measurement technology. Designs should minimize cost with an efficient balance between abatement and forest sequestration and should discourage adverse selection. They favor a national inventory approach linked to cap and trade that they feel will reduce problems of additionality, leakage, and permanence. They discuss advantages and disadvantages of the inventory approach compared to other policies.

It is my impression that scientific work in the natural sciences relating to climate change effects has relied heavily on computer simulations. So, too, have economists relied on computer simulations to trace economic effects of various climate policies. Dynamic global spatial-energy-economy-environmental models can be used to trace the cost, effectiveness, overall economic and distribution effects of various policies under a wide variety of assumptions. Section VI contains five papers describing results from five prominent models that consider the "impacts of alternative allocations of responsibility." Given the level of sophistication of these models and the nature of the book,

these chapters, of necessity, are a bit black boxish. However, they do give the reader a feel for model attributes, scope, and the kinds of questions such models have been used to address. They also suggest that the overall costs of climate mitigation are quite sensitive to the policies chosen while regional costs can vary highly depending on how the costs burdens are allocated.

In Chapter 23, Valentina Bosetti, Carlo Carraro, Alessandra Sgobbi, and Massimo Tovoni at Fondazione Eni Enrico Mattei in Italy use their World Induced Technical Change Hybrid (WITCH) Model to compare eight policy options: "global cap-and-trade with redistribution; global tax recycled domestically; reducing emissions from deforestation and degradation; climate clubs; burden sharing; graduation; dynamic targets; and R&D and technology development." They run their model from 2000-2100 for twelve regions and consider economic efficiency as cost measured as a percent of Global World Product (GWP), environmental effectiveness measured as emissions and temperature change, and distributional implications measured by Gini coefficients across regions. They use game theoretic arguments to compare political feasibility of the different policies by measuring whether a region is better or worse off after the policy and how many countries within a region are better off.

In Chapter 24, Henry Jacoby, Mustafa Babiker, Sergey Paltsev, and John Reilly of the Massachusetts Institute of Technology focus their dynamic computable general equilibrium model - Emissions Prediction and Policy Analysis (EPPA) –on a cap and trade system with allowances given away and then traded. They have 18 regions with a global target of a 50% reduction in GHG emissions from 2000-2050. They focus on mitigation costs by region under seven different allocation schemes. The three simpler permit allocation rules are 30% to developed/70% to developing, based on share of 2005 population, and based on inverse share of 2000 GDP per capita. The last four rules involve permit allocation along with full to partial compensation from developed to developing countries. They measure welfare costs as a percent GDP by region of both direct and terms of trade effects.

In Chapter 25, Leon Clarke, Kate Calvin, Jae Edmonds, Page Kyle, and Marshall Wise of the Pacific Northwest National Laboratory use their partial equilibrium MiniCam model of 14 world regions. The model includes agriculture and land-use along with a climate model. Their target is to limit atmospheric carbon to 500 parts per million by volume in 2095. They have four portfolios of exogenous technology scenarios. Three more advanced cases that variously allow carbon capture and sequestration, advanced biofuels, hydrogen, new nuclear, and other technical advances. The model runs suggest that none of these technology portfolios, by themselves, will achieve the requisite target. Thus they introduce two policies—a uniform carbon price on all emissions in all regions in each time period and different prices across regions with delays allowed for developing countries. Not surprisingly they find technology important in reducing costs with its importance increasing for the less optimal policy.

In Chapter 26, Geoffrey Blanford and Richard Richels of the Electric Power Research Institute and Thomas Rutherford of the Swiss Federal Institute of Technology in Zurich use the "model for estimating the regional and global effects of greenhouse gas" (MERGE). They recalibrate this intertemporal optimization model to reflect faster energy growth in China than had been expected when earlier runs were done. They consider two carbon policies that appear to operate through a carbon price that is endogenously determined. One policy keeps atmospheric CO_2 below 450 parts per million and the other below 550 parts per million. To meet the targets they consider three participation frameworks—no developing country participation before 2050 and two others where developing country participation is phased in faster. They report results for the U.S., China, India, other Annex B countries, low income non-annex B countries, and mid—income annex B countries. As with other modelers their simulations suggest that keeping CO_2 under 450 ppm is quite difficult and will require considerable contribution from developing countries. Even 550 ppm, although still possible, will require more commitment than seems likely given the progress to date.

In Chapter 27, Warwick McKibbin of the Australian National University, Adele Morris of the Brookings Institution, and Peter Wilcoxen of Syracuse University use the G-Cubed model to investigate whether quantity targets, such as cap and trade, or price targets, such as a carbon tax, are more robust in the face of changing conditions in the economy including an unexpected demand boom and a financial crisis. G-Cubed is a global ten region intertemporal computable general equilibrium model with thirteen industries. They find a quantity target doesn't work as well in booms because with the rising permit prices the model can actually slow growth in some other regions whereas a price based target works better. Alternately in a crisis, the quantity based approach will lower prices and may be countercyclical, providing some stimulus to growth. The price based approach in a crisis does not have such a counter cyclical affect. They use these results to argue for a hybrid approach that uses tradeable long term permits fixed in quantity that would permit a continuing level of emissions as well as short term annual permits that governments could issue at will but at a preset or negotiated fee. These later permits would function more like a tax than a quantity target.

The concluding section contains two chapters. Richard Schmalensee of the Massachusetts Institute of Technology considers of bit of history on climate negotiations from a U.S. vantage point and considers issues that make successful climate policy so difficult. Aldy and Stavins' in the last chapter provide sum up arguments. Although they do not promote a particular agreement architecture, they suggest the following core principals developed throughout the book. As this is an international commons problem it will require an international solution that does not compel nations to act against their own interests. As we move forward we will need to have lower carbon growth trajectories that are equitable, cost efficient, consistent with interna-

tional trade regimes, practical, realistic, verifiable, and will deal with trade-off between short-term development and long-term climate risk. Technology development and transfer is going to be a key component in dealing with all these issues and forestry management should be drawn in as well.

I very much appreciated this edited volume with its wide range of information and ideas. A lot of hard thinking about a very difficult problem by a group of very talented authors has gone into the project and the edited volume. I especially appreciated the discussions of linkages to trade, the success of trade negotiations and institutions that could serve as institutional models for climate negotiations and agreements. Also given the magnitude of the needed reductions and the political issues surrounding negotiating a solution, I found the ideas on how to negotiate policies and make them self-enforcing as well as suggestions on using portfolios of projects and selecting project that could fit in with local development goals intriguing.

Many of the chapters could be used as supplemental reading in courses relating to environmental economics and the political economy of international environmental agreements. Anyone interested in climate policy, especially economists and policy makers that are non-specialist in the area, but looking for a good overview of the problems and potential solutions, can benefit from this book. Although non-economists would not necessarily follow all of the economic arguments, the book gives both policy makers and the general public a sense of the urgency and difficulty of reducing emissions to the level that scientists are recommending.

This book was published before the disappointments of the 2009 Copenhagen meeting and meltdown of U.S. climate legislation. I believe a contributing factor to these failures is that a non-trivial portion of the world's population distrusts the scientific establishment and is not yet convinced about the seriousness of the problem. Although the length of the book is already a bit daunting, I would have appreciated a convincing scientific chapter summarizing in lay terms the latest scientific thinking on the potential climate impacts, where there is the most consensus on these impacts, and where there is the most uncertainty. A second issue that I would bring up for consideration is the fact that although the developed countries have contributed the lion's share of the emissions, they have also developed a vast wealth of technology. For example, cell phones are surely more energy efficient than the massive infrastructure needed for earlier land lines. Would fairness dictate some credit be given for these technical advances in future negotiations

I share the misgivings the authors express about being able to meet the suggested targets being bandied about—e.g. 450 ppm or even 550 ppm. Although the U.S. was rumored to have been ready to provide global leadership again, this has not yet come to pass. Should such intransigence remain, perhaps we should call this astute body of authors together again to focus on adaptation as the solution.

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Post-Kyoto International Climate Policy: Summary for Policy Makers, edited by JOSEPH E. ALDY and ROBERT N. STAVINS (Cambridge University Press: New York, USA. 2009), 210 pages, ISBN 978-0-521-13800-0 paperback, List Price $36.00.

These same editors also provide a shorter volume that is a summary for policy makers of the above longer volume. It contains the same information on contributors to the project, a similar introduction from Timothy Wirth, and the first two chapters are essentially the first and last chapter of the longer volume. Each of the other chapters are then summarized in appendix 1 with other appendices from the longer document listing individuals consulted, workshops and conferences, and a glossary including abbreviations. I found I was not always able to follow the arguments of the truncated versions in the chapter summaries and much preferred the richness of the complete volume.

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