Editorial

At present it is widely recognized that the only way to respond to the formidable challenge of climate change is to move swiftly towards an economy with a drastically lower level of GHG emissions. And this can only be achieved by developing and deploying new low-carbon energy technologies massively and as soon as possible. In the short and medium term, perhaps one or at most two decades, some of the existing technologies -with moderate improvements, presumably- will have to be used, but it is inescapable that a portfolio of new and/or still unproven technologies will be needed in the longer term. Then the key question now is how to achieve the prompt development and substantial generalized utilization of these new low carbon technologies.

This special issue of the European Review of Energy Markets brings together an ensemble of contributions that explore different regulatory approaches to attain a low-carbon energy future, preferably making these clean technologies happen at a global level, possibly in the context of a comprehensive climate regime. Most of the papers in this special issue were presented at the BP Forum on Energy and Sustainability "Promoting investment in low-carbon energy technologies" (http://www.upcomillas.es/catedras/bp/Foro_08.asp), organized by the BP Chair on Sustainable Development of Comillas University, as well as in the ECP High-Level Seminar on Positive Incentives for Climate Action, see http://www.ceps.eu/Article.php?article_id=588, which took place back-to-back with the BP Forum in Madrid on April 2008.

When trying to design regulatory instruments to promote low-carbon technologies one needs to address a number of significant issues: The volume of effort -global & for each technology-, the adequate timing for massive deployment of any given technology, the specific format of the regulatory scheme to be used to minimize the cost of meeting some objective, how to encourage cost reduction, how to harmonize regulatory schemes in different neighbouring markets and, finally, how to account for

potential side-effects. The first paper, *Promoting investment in low-carbon energy technologies,* addresses these open questions and discusses the preferred regulatory approaches to foster low-carbon energy technologies, within a global climate change regime, both from an academic and industrial point of view. It also provides practical recommendations for policy makers on the design of these policies. Specific promotion policies for energy efficiency and conservation, renewable energy, carbon capture and sequestration, and nuclear technology are examined, as well as the interactions between technology policies and climate change policies. The paper acknowledges the present limitations of purely carbon pricing approaches, because prices or taxes of the right strength to meet the above mentioned long-term carbon reductions are presently considered politically unacceptable, and therefore the signal provided by the current carbon prices for reducing emissions may be too low to incentivise investment in low-carbon technologies. This first paper introduces the main topics that are developed in more depth in the remaining contributions to this special issue.

The second paper, *Plugging the gap in energy efficiency policies: the emergence of the UK 'carbon reduction commitment',* examines the critical issue of the reasons for the lack of success of measures that aim at improving energy efficiency and conservation and the adequate measures to overcome these limitations. This is of critical importance, since it is widely acknowledged that this is the cheapest and quickest route to reduce CO2 emissions. Current estimations indicate that many of these measures would result in 'negative costs', i.e. a value of energy savings, discounted at a market rate of return, which exceed –sometimes very significantly– the up-front additional investment cost. The paper investigates a number of instruments already in place that aim at improving energy efficiency in the UK, as part of wider UK climate change policies, with particular reference to the business and public sectors. These instruments have failed to overcome key barriers that are specific to large, less-energy-intensive companies and public sector organisations, such as light manufacturing and the "service sector". This paper focuses on the adequacy of existing policy instruments to exploit the potential for energy efficiency, and the resulting policy implications. Besides, the paper introduces an entirely new proposal – the Carbon Reduction Commitment - which is the main new policy instrument in the UK's 2007 Energy White Paper and is due to commence in 2010.

A subset of the approaches to promote energy efficiency and conservation are those that aim at increasing the capability of the demand of electricity to

respond to a diversity of signals, which may range from spot market prices to direct requests from the system operator to reduce load under emergency conditions. There is a long tradition of the so-called demand response programs. The third paper *Electricity demand response tools: Current status and outstanding issues* is the result of a thorough review of existing and planned international experiences in electricity systems, with the objective of reflecting on those still open issues that will necessarily have to be addressed to make progress in this field. Technological advances in electronics and telecommunications enable both consumers and system operators to manage demand in a diversity of forms. Smart meters will be the key elements in advanced demand management systems, together with other devices such as smart thermostats, lighting control systems or under voltage or under frequency relays. Economic incentives include a great diversity of cost-reflective tariffs, as well as incentives to participate in the spot market or to reduce demand, as for instance the recent experiences with white certificates. Numerous studies have been performed to evaluate the actual impact of these measures on the behaviour of electrical demand. The regulatory decisions on the responsibilities of retailers and distributors, or the unbundling and standardization of the metering service happen to be of critical importance for the success of measures to enhance demand response.

A massive utilization of renewable energy sources for electricity generation (RES-E) is undoubtedly an essential ingredient of the future low carbon energy model. Since diverse market failures may prevent RES-E to compete on a level playing field with other more established technologies, some regulatory support is justified. Several economic, institutional, political, legislative, social and environmental barriers have to be overcome. The fourth paper *Regulatory instruments to deliver the full potential of renewable energy sources efficiently* identifies which regulatory issues are of major relevance with respect to promotion and grid integration of RES-E, critically reviews alternative schemes and makes proposals in the context of a massive penetration of these technologies. In particular the paper explores two major issues. First, the adoption and implementation of adequate regulatory financial support systems: Here the most controversial issue is whether quantity-based instruments (e.g. guarantee-of-origin trade, tradable green certificates or renewable portfolio standards) or price-driven instruments (e.g. feed-in tariffs or investment support systems) are preferable under a societal point of view. Second, the design of a clear regulatory framework for network cost allocation policies to integrate RES-E in the electricity

grids. At present these policies are very heterogeneous among different EU Member States. The most prominent open regulatory topics in this regard are: the adoption of a deep, shallow or super-shallow approach in the implementation of network charges, and the creation of market mechanisms for system balancing and operation to manage the variability and intermittency risk of the dominant RES-E generation technologies.

The search for a lower carbon future has to contemplate also how to best deal with the supply to those 1.5 billion people, about 30% of the world population, still without access to electricity. There is an emerging consensus that electric energy is a necessary, although not sufficient condition, for economic growth, especially when addressing rural development. In the least developed countries, as in Sub Saharan Africa (SSA), climate change mitigation is not the first priority, so least-cost options should be pursued, although still with a concern for a cleaner development. The fifth paper, *Compatibility of rural electrification and promotion of low-carbon technologies in development countries: the case of Solar PV for Sub-Saharan Africa*, revises actual electrification experiences, analyzes the trade-offs between climate change objectives and development objectives and examines the relevance of different possible regulatory approaches and the pros and cons of each one of them. In particular the paper concentrates on a specific technology that has proven to be useful and successful in SSA at least, Solar Home Systems (SHS), with more than half a million of systems presently installed in Africa. The paper describes and critically reviews five regulatory approaches to provide SHS in a massive way in developing countries. Different perspectives are considered: a) how to achieve the lowest fees for final consumers; b) the relevance for each method of other crosscutting elements, such as long-term political commitment, inclusion of the established financial sector and the subsidy levels; c) specific conditions that need to be fulfilled simultaneously before a market can develop: affordability, good governance, sound national economic politics and international trade politics.

It will take time to overcome the inertia of the present energy supply model regarding its high ratio of consumption of fossil fuels, despite the strong efforts that are expected in the deployment of low carbon technologies. Precious time could be gained, until these new technologies are available, if CO2 emissions from burning fossil fuels in large combustion facilities could be captured and safely stored at a reasonable cost. The sixth paper *Model-based evaluation of European carbon capture and storage policy options* investigates the

prospects of carbon capture and storage (CCS) in the European energy system, as a mean of supporting the climate mitigation efforts of the EU. However, two problems have to be solved to enable the deployment of CCS. The first is to ensure that stored CO2 remains isolated from the atmosphere and biosphere, and so the technology is environmentally secure and effective as a climate change mitigation option. The second is to address commercial barriers to the deployment of CCS by appropriate regulatory interventions since, once more, if entirely left to the market, investments in CCS technology development may be insufficient because of a diversity of market failures. The paper provides an overview of the major economic, environmental and social impacts of a range of policy options aiming at internalizing the externalities related to CCS. The specific options considered in the paper are: not enabling CCS, enabling CCS under the EU-ETS, imposing obligations for mandatory CCS on new and/or existing power plants and subsidising CCS deployment. The quantitative analysis is based on a combination of a systems approach, using the large scale partial equilibrium energy systems model PRIMES, and some further ex-post analysis of the model's results.

The seventh paper, *Financing the nuclear renaissance,* examines the economic issues associated to the possible return to the building of new nuclear power plants (NPPs) in Western Europe and the US, with a focus on the key risks involved. It should be remembered that, among the several factors that contributed to the abandonment of nuclear power during the late eighties and nineties, of particular relevance for the topic investigated in this paper has been the regulatory trend towards liberalized electricity markets, with a consequent increase in the risk to obtain an adequate return on investment in generation assets. It is well known that the lifetime net-present–value of the total costs of nuclear electricity production is dominated by capital costs. Besides, between the decision to proceed with the project and the first sale of a unit of electricity with a NPP there would typically be a gap of at least ten years. It is during the interval from five to ten years when the largest costs (construction of the plant) are typically incurred and when the engineering, political and project finance risks become most acute, since a partly completed power station is almost worthless and any time delay is very expensive because of the capital sunk in the project. Those risks will affect the rates of return expected by potential private investors. The paper also factors in its analysis the claims that have been made by NPP design companies that their newer designs will be simpler, quicker and cheaper to build, the risks associated with international fuel trading in a world of

evolving geopolitical risks, the price that is expected to be applied to greenhouse emissions now or in the future, as well as the price of fossil fuels, all of which contribute to provide an economic case for NPPs. The paper examines the implications of current regulatory approaches in the European Union and the US on the prospects for nuclear new build in each case.

Uncertainty in climate policy creates a barrier for investment in low carbon technologies, by introducing a potential future shock in the price of carbon, to be added to its inherent volatility. The eighth paper, *Risks and uncertainties in low-carbon energy investments,* examines the impact of uncertainty in climate change policy on the investment decisions in the power sector and, conversely, it analyzes how these policies should be shaped to facilitate investment. Potential investors may decide to postpone their decision until major regulatory uncertainties disappear. The paper uses real option theory to quantify the effect of policy uncertainty and to review the regulatory instruments that could be used to hedge against these risks, both from the potential investors and the governments' viewpoint. In the absence of adequate risk hedging instruments, the carbon price that will be required to trigger investment is expected to be significantly higher that would be expected if risks were not taken into account.

Low-carbon technologies can be furthered by climate policy instruments -such as cap and trade, carbon taxes or standards-, but also by measures directly addressed to promote technological innovation in these specific areas. However, some market failures may significantly reduce the effectiveness of innovation measures designed to complement climate policy. And, conversely, climate policy may not be able to stimulate innovation, or it may not have a sufficient effect of reduction of the GHG emissions. The ninth paper, *The interaction between carbon and technology policies*, identifies the several reasons why climate and technology policies are unlikely to be fully synergic. The WITCH model, a hybrid climate-economic model of the world economic system, is used to illustrate this point for a relevant situation of integration of carbon and technology policies: the combination of a cap-and-trade scheme with public expenditure for climate-related R&D aimed at improving energy efficiency.

All policies and approaches described in these past papers have focused on a national or regional, mostly bottom-up approach to developing cleaner technologies. But in order to become widespread, these initiatives should

possibly have to be incorporated to a global agreement on climate change. The remainder of this special issue is devoted to how to address specific areas of this future agreement.

The adversary approach has been dominant in the approach to climate change by most governments. Besides, agreements at governmental level are defined in broad terms, far from the specific targets that the private sector needs to initiate any practical action. By contrast, global sectoral industry approaches are based on cooperation and specific technology-based bottom-up commitments. Sectoral approaches have received explicit support at the Bali summit in December 2007 and will be a component of the negotiations for the post 2012 agreement. The tenth paper, *Climate change: which of the different sectoral approaches can be implemented?* explains the advantages of sectoral approaches, presents a typology and describes the main categories and most relevant experiences. The paper also examines the common elements to these initiatives, as well as the main challenges that they face.

The eleventh paper *The Bali roadmap and North-South cooperation: the right to development in a climate-constrained world*, draws attention to the different level of commitment that should be expected from developing and developed countries –North and South- in meeting the very stringent emission reductions that are compatible with a long-term low carbon global economy. By means of a simple "thought experiment", the paper shows that carbon-based growth is not an option, neither in the North nor in the South, and that any scheme of burden sharing has to recognize this and make the alternative a reality. However, while the control of emissions in the South is an undeniable scientific necessity, at the same time the South justifiably has the struggle against poverty as its first priority. Linking reductions in the South to support from the North offers the only possible solution to this dilemma. The paper presents a specific approach – the "Greenhouse Development Rights" or GDR framework – whose central principle is the right to development, rather than a right to a certain amount of emissions. Under GDR those individuals under a predefined development threshold are not expected to share the burden of mitigating the climate problem. On the other hand, above the development threshold, in any country, individuals are expected to shoulder this burden, on the basis its economic capacity and their responsibility in emitting GHG. In this way, the paper draws attention to the vast level of financial assistance and technological cooperation that the climate problem demands from each country.

The previous paper sets the scene for the twelfth one. *A bottom up approach for India,* which presents a realistic appraisal of the current close relationship between economic development and energy use in India, describes the existing policies and measures that have been adopted by the Indian Government, identifies potential mitigation opportunities in several selected sectors as well as the existing barriers to exploit these opportunities, and proposes additional measures to remove these barriers while maintaining development as the first priority. Per capita commercial energy consumption in India is still very low and it is well known that no country has significantly reduced poverty without a substantial increment in energy utilization. The challenge facing India is to meet its energy needs in a sustainable manner, and finding its own solutions to the very specific features of its energy sector. By adopting a bottom-up approach, the paper identifies numerous activities with strong GHG mitigation potential, many of which can pay for themselves, mostly in the area of energy conservation and efficiency improvement. Domestic policy actions and international support schemes are suggested to remove barriers that might impede the successful implementation of the proposed mitigation and adaptation activities.

As guest editors, we thank the authors for their brilliant contributions to shedding some light on this difficult and multifaceted topic, and to Jef Dermaut for his very effective assistance in making this special issue a reality.

Guest Editors
Ignacio J. Pérez-Arriaga and Pedro Linares[1]

[1] Ignacio Pérez-Arriaga is the Director of the BP Chair on Sustainable Development and Professor at the School of Engineering, Instituto de Investigación Tecnológica, Universidad Pontificia Comillas, Madrid, Spain. He is member of the Spanish Royal Academy of Engineering, Director of Training at the Florence School of Regulation, within the European University Institute, in Florence, Italy, and independent member of the Irish Single Electricity Market Committee. Presently he is a visiting professor at the Center for Environmental and Energy Policy Research, MIT, Boston, USA.
Pedro Linares is Associate Professor of Industrial Organization and Head of the Department of Industrial Engineering at Universidad Pontificia Comillas, Madrid, and Research Associate at the Harvard Kennedy School and FEDEA.