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Backcasting a Future of Sustainable Energy: A Public Policy Perspective

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1. Introduction

Although the adoption of renewable energy is perceived as a means to enable delivery of emission-free solutions, its penetration into the energy market has not been timely and significant enough to make a material impact on the structure of the global energy system. Using backcasting as a policy tool for developing a view of a sustainable energy future, this Chapter aims to explore some of the critical hurdles as the policy makers continue to formulate and advance environmentally friendly energy consumption in order to mitigate the impacts of climate change. We illustrate the nature of the challenges to reach a wider adoption of alternative energy resources and build on the need for renewal of the energy "delivery" infrastructure through the "smart grid" as a means for transition to a sustainable economy in the longer term.

While there is now engagement with the public about a sustainable future, alignment of stakeholders' economic interests and absorption capacity of emerging technologies remain as the two main challenges in mitigating the underlying systemic hurdles to be overcome. As the public at large realize the need for a future of sustainable energy despite lack of a global consensus about definitive targets, the policy makers may seek to provide a combination of approaches that build on optimal investment incentives in the near-term, liberalization of the electricity grids in the medium term and a dynamic policy framework that induce continuous technological innovation in the longer term. Observing the current responses to the externalities by the policymakers in a number of jurisdictions we articulate such forthcoming initiatives to mitigate the systemic hurdles embedded in the existing energy infrastructure. We also articulate measures to enable deployment of integrative sustainable energy solutions over a transformed infrastructure, namely smart grid.

2. Backcasting a future of sustainable energy

Prior and current studies of energy use have confirmed the problems with the deterioration of air quality and the consequences of lingering reliance of fossil fuels in the modern global economy. The public concern about sustainability of the environment and the ongoing issues with climate change remains an important driver of social and political influence. Advocates, mainly from the developed economies have argued for a set clear objectives and targets on emission of Greenhouse Gases (GHG). There is, however, no unanimity and divergent perspectives emerge as at the core of the debates across the globe. Individual countries at different stages of economic development have advocated to jointly limiting their emission to a certain level in response to the adverse effects resulting from climate change. Such an initiative resembles the concept of backcasting for an end point in time with a pre-determined target (Robinson 1982; Ng 2009). Under such an initiative, a future of sustainable energy with a cap on GHG emission is desired as target.

Such multilateral negotiations have proved to be highly challenging given the complexity of politics involved with respective jurisdictions and the diversity of stakeholders' interests. This was demonstrated in the UN Climate Summit held in Copenhagen December 2009 where multilateral agreements over specific target or cap were attempted but failed inevitably.[1]

3. Challenges at the policy level

3.1 Rethinking the targets and constraints in backcasting

Although the stakeholders tend to concur on the broad need to deal with issues of climate change and the desire to improve sustainability, there is no coherent plan or a clear road map to a sustainable future. Some argue that there is not sufficient political will among the major players to drive the conclusion of a target at a future point in time (BBC 2009). There are concerns that the un-reconciled targets among the nations would hamper any further progression towards a sustainable future.

In the backcasting methodology, however, it is suggested that while it is critical to have a certain degree of consensus among the key public stakeholders, such a consensus for practical purposes is only around qualitative values. (Robinson 2003). Further development of specific targets would take place at another level on which the local stakeholders might seek more precise sub-optimal targets. In reality, this would be an iterative process with end points and scenarios guiding the process of planning towards the future prior to specific quantifications (Ng 2009).

As reflected in the current public policy formulations among various jurisdictions, the momentum to improve sustainability is still observable despite their respective variations in pace and strategy. Allegedly there are differences in constraints among the political systems as well as in embedded objectives. While some jurisdictions might be accustomed to more explicit and definitive commitments, some might have practical concerns over commitments that could be disagreeable by domestic stakeholders. For instance, the European Renewable Energy Council (EREC) has developed a detailed roadmap and specific renewable energy consumption target of 20% by 2020 (Zervos and Lins 2010); such a target could be exceeded by another 20% with reference to the assumption that EU might have even implemented a more ambitious roadmap. Other advanced economies, such as U.S. and Canada however have not developed a national target despite commitment devised by certain states and

1 BBC (2009) reported on the various reasons for the failure of to reach an agreement with quantifiable measures and noted, "The logical conclusion is that this is the arrangement that the big players now prefer - an informal setting, where each country says what it is prepared to do - where nothing is negotiated and nothing is legally binding."

provinces. China, another major player in the global economy, has voluntarily to set a target of 15% by 2020. The variations in commitment among these major economies is evidence of the differences in pace of economic growth, existing energy portfolio mix and the level of advancement and implementation of renewable energy technologies in the supply mix.

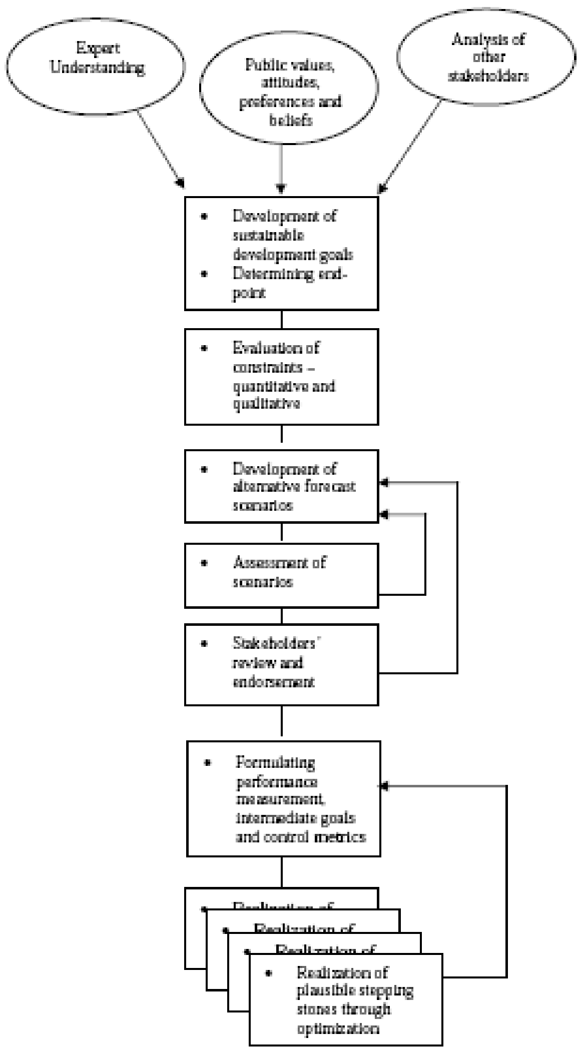

Fig. 1. Backcasting framework for the renewable energy sector (Ng 2009)

3.2 Optimization under moving targets

Although there are no confirmed targets set through multilateral agreements, this has not dampened the furthering of policy initiatives to improve the sustainability of energy supply. It is understandable that politicians have difficulties in committing to targets that have short term ramifications on energy supply security, prices and affordability and reliability. Under the preferred voluntary approach, individual countries influenced by both international and domestic political pressures continue to admit their concerns about over reliance on fossil fuels. The public at large has increasingly acknowledged the cost of such externalities to the environment and to the health impacts, which are seen as the common values and constraints agreeable among the human beings. While more resources are being allocated to develop and build capacity of renewable energy, the approach and roadmap to a scenario of sustainable energy would still be subject to subsequent transformation of the energy infrastructure as well as technological advancement for renewable energy resources. In other words, the jurisdictions would continue to seek their individual plausible stepping stone through optimization (Ng and Nathwani 2010).

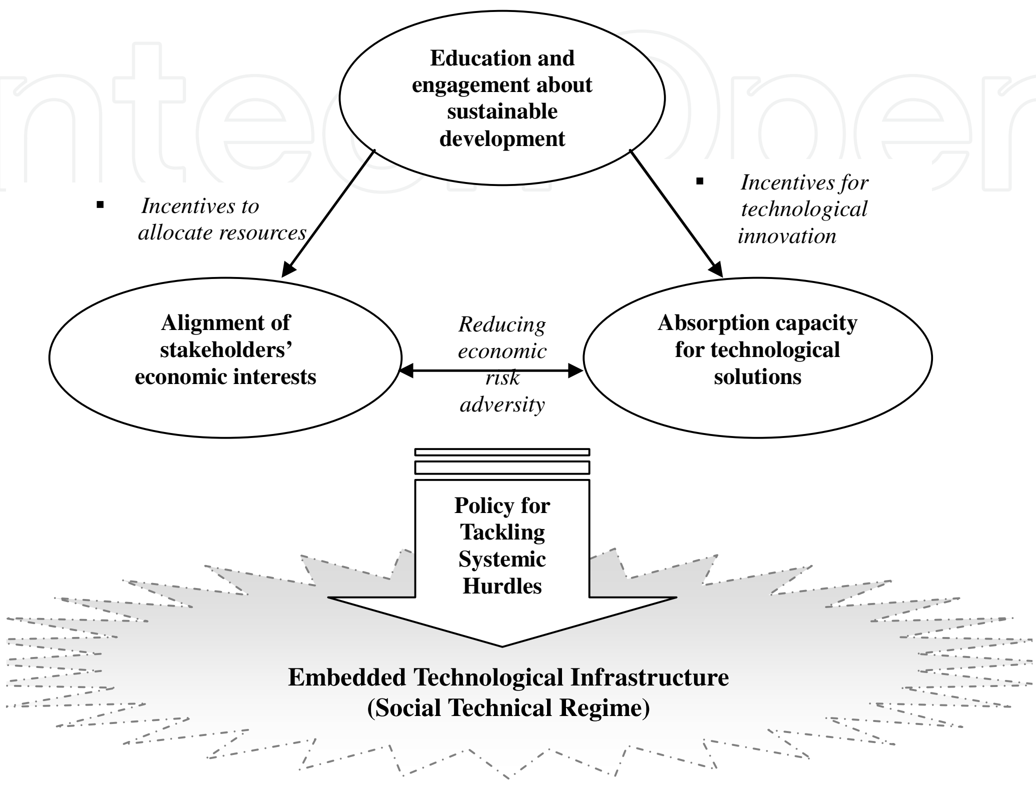

Fig. 2. Dynamic policy development towards a future sustainable energy (Ng and Nathwani 2010)

4. Emerging country policies to embrace sustainable energy

4.1 Inducing multiple sources of renewable and sustainable energy

As we move into a future of sustainable energy, the dominance of fossil fuels would have to be replaced by a more balanced mix of energy options as suggested by Fanchi (2004). Among the mix, the most convincing sources would seemingly be composed of hydro, solar, wind, geothermal and wave, depending on the geographical dimensions. In order to ensure stability of electricity loading and energy supply, the use of nuclear energy is likely to be maintained and even increased for its complementary characteristics and carbon-free in emission.[2] Fossil fuels, including natural gas, would still be a likely source for vehicles until a more extensive application of electric and hydrogen-fueled vehicles.

In recent years, policy makers have attempted a number of approaches ranging from command and control through regulations to incentives such as Feed-in Tariffs (FITs) to

[2] See Nathwani et al, (1992) and more recently Mackay (2009) in his exploration of a balance sheet of energy production and energy consumption.

Renewable Portfolio Standards (RPS) to promote the development of renewable energy sources through private investments. Stability of a policy framework and the supporting governance models are considered critical to inducing new investments for renewable energy and they will vary from context to context in different countries and political systems. For instance, clean tech ventures are viewed as the next major investment focus among the venture capitalists in the U.S. as the pertinent policy unveiled (Pernick and Wilder 2010). In Canada, the study by Holburn et al. (2010) revealed the influence of pertinent policies to induce initial investments in wind power. On the other hand, emerging ventures have not only expanded in the domestic market but could swiftly tackle international markets where accommodating renewable energy policies are in place as demonstrated in the emerging renewable energy sector in Germany (Jacobsson. and Lauber 2006).

4.2 Three stages of development

For further development of renewable energy sources, a stable policy framework is necessary and complementary for the growth and development of an industry that can be stimulated by positive economic incentives. For example, Germany introduced FITs to stimulate the direct investments of solar energy and wind power converted into electricity sold through grids to the end customers giving a boost to early stage development. Such measure enables the nurturing and development of new ventures in renewable energy as well as the growth of pertinent knowledge and technology. The perceived investment risk and cost of capital for such early-stage development by a firm would be reduced as a consequence.

In the next stage of development – the medium term, the policy makers would see the need for the development of an infrastructure that intelligently enhances the supply of renewable energy. For instance, one of the key problems of GHG relating to emissions from fossil-fueled vehicles would be mitigated through an extensive adoption of electric vehicles. In particular, the development of a smart grid[3] would enhance the development and growth of alternative energy sources while providing sufficient electricity supply to extend the use of electric vehicles. The end users will be empowered to choose their choice of energy through an intelligent platform for demand and supply.

In the third stage of development, sustainable and yet competitive industry, emergence of a sustainable and yet would encourage business competitions through a smart grid that is widely open to multiple sources of renewable energy producers as suppliers of energy to the grid. This smart grid system would facilitate the development of a technological regime under which technological innovation will be promoted and efficiency of renewable energy will be further enhanced under an economic model near pure competition (World Economic Forum 2009). For instance, solar energy ventures need continuous technological innovation so as to make solar energy as a viable solution under the current technological regime of the electricity market. In the next decade, the cost of solar panels could be drastically reduced within the next generation of solar energy through technological advancement in efficiency and mass production (Dhere 2007; Pernick and Wilder 2010).

Nonetheless, the combination of other emerging renewable energy sources as well as development of complementary policy and technological infrastructure could perplex the

3 See Report of the Ontario Smart Grid Forum 'Enabling Tomorrow's Electricity System,' IESO (2009).

landscape (Johnston et. al., 2005; Johnson and Suskewicz, 2009; Ng and Nathwani, 2010). Reaching this stage of relative market liberalization, an open market for competition through smart grids would, for instance, promote swift development and applications of more efficient solar panels into the electricity markets.

Fig. 4. A scenario of smart grid system in the future[4]

5. Approaching the medium term – the arrival of smart grid

5.1 The significance of smart grid

As the smart grid technology becomes feasible, the policy makers become increasingly convinced for its complementarity to sustainable energy. Smart grid could help create a landscape for rapid technological innovation envisaged by Grin (2008). The development experience of 3G networks in the telecom sector and the innovation of smart phones would resemble the potentials of smart grid. Effectively, smart grid would enable consumer empowerment and incentives through real-time information, time-based pricing and utility-based demand controls. It would also facilitate net metering for consumer-based renewable energy generation through solar and wind, etc. Smart grid in short represents an opportunity to transform the existing infrastructure into one that delivers improved efficiency and optimal capacity utilization as the consumers would ultimately be empowered to choose the most competitive and yet sustainable sources through their smart grid. Remote sources of renewable energy despite issues with their loading stability, including solar and wind, would be extracted and integrated into smart grid so as to maximize their potentials to maximize their potential under a balanced mix of sustainable energy sources.

5.2 The frontiers from the east and west

While Fanchi (2004) expressed the potential variations in energy sector development among the various civilizations of the world, differences in the renewable energy development

[4] Source: European Technology Platform SmartGrids

models among countries in the east and west could be assumed. Although it is observed that there are frontiers in the east and west which have commenced their races towards sustainable energy through smart grid developments, there may well be variations in approach, namely between the centralized planning in China and the market-driven ones in the United States. The key initiatives among the frontiers in smart grid from the east and west are summarized in Table 1.

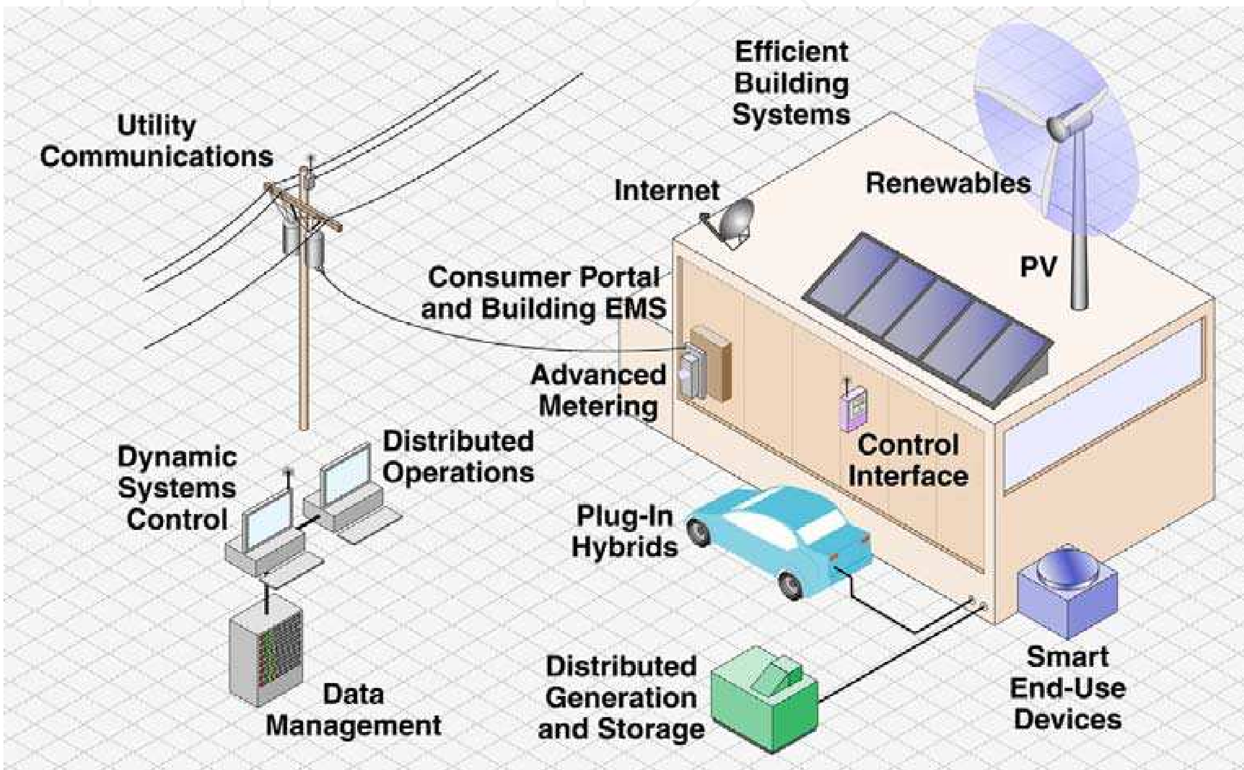

Fig. 4. A schematic of smart grid utilization [5]

East Asia	Europe	North America
China • Set forth a $586 billion stimulus plan to invest in water systems, rural infrastructures and power grids, including a smart grid system. • Prepared to invest $7.3 billion this coming year in smart grid technology, edging out the $7.2 billion in U.S. investments • Aim to reduce its overall energy consumption and make the power distribution network more efficient. As part of the efforts to reduce energy	**France** • Plan to use smart grid to stabilize and to efficiently unify dispersed energy supply as 78% of power produced is from nuclear power whereas coal, natural gas, bio-meth and wind power are all various methods used to produce power. • Suggested integrating renewable energy and supplying smart meters	**Canada** • National smart grid implementation will depend on each province since the electricity system is under provincial jurisdiction. • Ontario declared "Green Energy Act as a comprehensive government policy action. Ontario Energy Board in Canada mandated a large scale

[5] Source: Electric Power Research Institute

consumption, smart grid systems are being considered. **Korea** • Made a tentative deal with Illinois to jointly develop and test technologies for smart grid. The two parties will set up a pilot program to create smart grid technology at a facility on Jeju Island. Under the plan, technologies that are developed through this partnership and are deemed viable for commercialization will be rolled out both in Illinois as well as in Korean cities. The Korea Electro-technology Research Institute and other related local centers will collaborate with Illinois' Argonne National Laboratory. • The Korean government seeks to complete the installment of smart grid in the country by 2030 and establish another 27,000 or more power charge stations for electric cars. A total of 27.5 trillion won will be injected according to the roadmap. The government plans to handle it by developing core technology, new markets, new infrastructure and attracting voluntary investment from businesses. **Japan** • Announced a national Smart Metering initiative and large utilities companies announced Smart Grid programs to commence in 2010. • A consortium of well known Japanese companies, formed by Hitachi, Toshiba, Fuji, and Panasonic, plans to construct a working Smart Grid system in New Mexico by 2010. The effort is led by Japan's public research and development organization for environmental	to reflect consumer's demands • France' energy environment public corporation ADME (Agence de l'Environnement et de la Maîtrise de l'Energie) supports electric vehicle technology-related research and formulated a smart grid roadmap. • Planning to substitute old fashioned electricity meters by smart meters by 2015 in all households. **UK** • The British Department of Energy and Climate Change (DECC) and the regulator Ofgem published a smart grid route map. A U.K. smart grid could be delivered to contribute to the realization of government carbon targets and end-customer benefits. • The route map was developed by the Electricity Networks Strategy Group (ENSG) aiming to realize the U.K.'s smart grid vision. • Focus on critical smart grid roles for the nation's planned low carbon transition up to 2050, including the integration of inflexible generation, the electrification of transport and heating, as well as integration of distributed energy resources. • Three high level objectives include carbon reduction,	smart grid initiative by upgrading from traditional Automatic Meter Reading (AMR) to Advanced Metering Infrastructure (AMI), a system capable of measuring and analyzing energy usage using two-way communication, throughout the province. The province plans to implement smart meters in all household by 2010. • Issues of standardization, security, maintenance and regulation remain a concern while continuing talks between President Obama and Prime Minster Harper implicate a definite movement towards smart grid. **U.S.** • Development of smart grid in the United States is stimulated by the $4.5B USD allocated to grid modernization under the American Recovery and Reinvestment Act (ARRA). • Research in promising technologies for smart grid implementation under the Smart Grid Demonstration Program (SGDP), which allocated $100M USD to regional smart grid demonstrations and $515M USD to energy storage demonstrations. The Smart Grid Investment

technologies, NEDO (New Energy and Industrial Technology Development Organization). The Japanese government is expected to co-invest between $20.3 and $30.4 million in the project composed of digital monitoring and distribution of power as well as solar power generation and storage. The consortium will retain ownership of the grid and control it in large part via the Internet.	energy security, and economic competitiveness and affordability in delivering a cost effective low carbon transition.	Grant (SGIG) programs also allotted $3.3B USD towards the quick integration of proven technologies into existing electric grid infrastructure. • Renewable Portfolio Standards (RPS) for production of energy from renewable sources adopted under state legislation.

Table 1. Key policy initiatives for smart grid development in the world [6]

6. Concluding remarks: towards a scenario of market forces for sustainable energy

As we look backward from a future scenario of multiple sources of sustainable energy, the world today is posed to upgrade its existing energy infrastructure that would intelligently enable us to embed sustainable policy that benefits the coming generations of the human race. To achieve that scenario, we need to continue to develop policy that enables the electricity and energy industries to undergo a mission-critical transformation. In particular, finances and investments should be stimulated for resources allocation into the development and upgrade of the existing infrastructure at a level of risk that is commensurate with the benefits derived from a safe and secure network that provides delivery at a high level of reliability. At the same time, there ought to be well-planned reform of the existing electricity sector in order to facilitate a comprehensive utilization of the smart grid system. In particular, ownership structure of the pertinent assets should promote sufficient fair competition driving the development of a wide landscape of technological innovation for renewable energy as envisaged by Grin (2008).

New industries for renewable energy and pertinent infrastructure are expected to be built in the coming decades. A strong and stable policy framework plus confidence in the governance of the energy sector will enhance the corresponding value chains development as well as complementary ventures invested and nurtured as a consequence. Given the scale of developments, there will essentially be cross-border collaborations to optimize the strengths of different jurisdictions in building up the value chains for the emerging industries of solar panels, wind turbines and other supplies for building smart grid infrastructures. Nevertheless, the world now needs to learn about these emerging technologies and the knowledge to deploy these intangibles continuously in an innovative manner in order to reach a future of sustainable energy. The positive dynamics among the policy makers, the industry innovators and the general public would need to be engendered swiftly prior to an end point in backcasting.

[6] The table is a summary of the recent studies by Korean Smart Grid Institute (2010).

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Paths to Sustainable Energy
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The world's reliance on existing sources of energy and their associated detrimental impacts on the environment- whether related to poor air or water quality or scarcity, impacts on sensitive ecosystems and forests and land use - have been well documented and articulated over the last three decades. What is needed by the world is a set of credible energy solutions that would lead us to a balance between economic growth and a sustainable environment. This book provides an open platform to establish and share knowledge developed by scholars, scientists and engineers from all over the world about various viable paths to a future of sustainable energy. It has collected a number of intellectually stimulating articles that address issues ranging from public policy formulation to technological innovations for enhancing the development of sustainable energy systems. It will appeal to stakeholders seeking guidance to pursue the paths to sustainable energy.

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