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1.1 Energy Demands and Challenges

Energy is no doubt the engine that promotes human civilization and development. Achieving secure, clean and sustainable energy production, storage, and consumption are, perhaps, the greatest technical and social challenges that the world are facing [1–6]. Generally, energy sources could be divided into two categories based on their intrinsic nature: non-renewable sources and renewable sources. Non-renewable energies include fossil fuels, natural gas, oil and coal, are available in limited quantities on the earth and could not be re-generated within a short span of time. Renewable energies are energies that are inexhaustible, and could be generated repeatedly when required, such as solar, wind, geothermal, tide and biomass. It is projected by the U.S. Energy Information Administration that the world energy consumption will grow from 524 quadrillion British thermal units (Btu) in 2010 to 826 quadrillion Btu in 2040, a 56 percent increase between 2010 and 2040 (reference case) [7].

With rapidly growing energy demands and concerns over energy security and environmental pollution, it is highly desirable to explore renewable and sustainable energy sources. It is anticipated by Russia International Energy Agency that the share of renewable energies in primary energy consumption will rise from 13% in 2011 to 18% in 2035, resulting from rapidly increasing demand for carbon renewable sources to produce heat, generate power and make transport fuel [8].

Wind power and solar photovoltaics (PV) are the world's fastest-growing renewable energy. Wind and solar would account for about 15% of global installed power capacity, and reach almost 35% of that of the European Union in 2035 according to the New Energy Scenario [8]. However, unlike dispatchable power generation technologies (fossil fuel-fired, geothermal, hydropower with reservoir and bio-energy), which may be ramped up or down to match demand, the output from wind power and solar PV is only intermittently available and is strongly dependent on the availability of the sources including the time, weather, season and