Renewable Energy 92 (2016) 293–302

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

India's energy system transition—Survival of the greenest

B. Sudhakara Reddy

Indira Gandhi Institute of Development Research, Goregaon (E), Mumbai 400065, India

ARTICLE INFO

Article history:
Received 20 March 2015
Received in revised form
25 January 2016
Accepted 8 February 2016
Available online xxx

Keywords:
Emissions
Green energy
Fossil fuels
Green jobs
Scenario

ABSTRACT

The transition to a clean and green energy system is an economic and social transformation that is exciting as well as challenging. The world today faces a formidable challenge in transforming its economy from being driven primarily by fossil fuels, which are non-renewable and a major source of global pollution, to becoming an economy that can function effectively using renewable energy sources and by achieving high energy efficiency levels. In the present study, a green economy scenario is developed for India using a bottom-up approach. The results show that significant resource savings can be achieved by 2030 through the introduction of energy-efficient and green technologies. The building of a green energy economy can also serve another purpose: to develop new 'pathways out of poverty' by creating more than 10 million jobs and thus raise the standard of living of low-income people. The differences between the baseline and green energy scenarios are not so much the consequence of the diffusion of various technologies. It is the result of the active roles of different actors and the drivers that become dominant.

1. Introduction

In modern economy, energy is fundamental to virtually every product and service in use. It has been developed on the dependence of abundant and easy-to-transform polluting fossil fuels. The insatiable hunger for energy has resulted in a dismal air quality across the countries and is a constant reminder of their reliance on fossil fuels. On one hand, increase in population and income levels combined with increased per capita energy consumption requires energy production to keep pace with economic growth, and on the other, the impact of fossil fuel use on environmental degradation is enormous [27]. The conflicting policy objectives of protecting the environment while increasing economic growth and employment has resulted in this paradox. Hence, it is important to decouple economic growth from environmental degeneration. The need for abundant energy sources that do not pollute environment while ensuring energy security is one of the greatest technological challenges of the 21st century. Hence, the search for green energy involving affordable, low-carbon, and renewable energies has become global priority[21,29].

The approaches to green economy include increasing device efficiency, fuel switching (from non-renewable to renewable energy), and decreasing energy intensity of the industrial processes and transportation modes. Various studies suggest [19,20,24,29] (Jebli 2015) that transitioning to a green economy has economic and social benefits from the perspectives of the government and the society. From the government perspective, this results in significant resource savings, reforming existing polices, designing new incentives to consumers, strengthening market infrastructure and market-based mechanisms, and redirecting public investment. From the society perspective, this provides an opportunity for savings in energy use, reduced health costs and increased employment opportunities.

This paper explores a transition to a sustainable energy system using the socio-economic-technical scenario method [14,27,29]. This approach takes into account the multifaceted nature of transitions which not only require the development and use of new technologies, but also of changes in user behaviour, policy and regulation.

The scenarios that are developed are: baseline business as usual (BAU) as well as green energy (GE). The purpose is to illustrate, by example, how a country can try to green its economy and what are its advantages in terms of resource savings and job creation. Our scenarios are, to a great extent, based on the existing technologies. The proposed measures used in the scenario substantially reduce dependency on fossil fuels by 2030. The challenges to this path lie in socio-economic-political domains.

2. India's energy trajectory

A combination of rising incomes and population growth fuels

E-mail address: sreddy@igidr.ac.in.

http://dx.doi.org/10.1016/j.renene.2016.02.027
0960-1481/

energy use. In India, between 1960 and 2010, the primary energy consumption has increased six-fold from 117 to 715 MTOE while the non-commercial energy just doubled. Coal is the major energy source and has provided 80% of the total primary energy use in 1960 but only 51.8% in 2010. The consumption grew most quickly in the oil and natural gas sectors, with an increase of about 4.2 and 3.6% respectively. The increase in other renewable sources like solar, wind, small hydro, hydrogen, geothermal forms is just about 1% per annum. The share of non-commercial energy in total had decreased from 63.5 to 31.6% [23] The per capita energy use and carbon emissions between 1960 and 2010 have increased from 0.26 to 0.59 TOE and 0.07–0.45 tons, respectively (Table 1). Even though energy consumption has increased six-fold, the increase in per capita use has only doubled largely because of the shift from inefficient to efficient devices/carriers. The increased energy use has resulted in a large increase in CO_2 emissions. Even though, per-capita emissions are relatively lower when compared with other developing economies, due to its large population, the total emissions are high.

The capacity of power plant generation in 2010 was 174.5 GW and produced 964 GWh of electricity. Thermal power plants accounted for over 60% of the installed capacity and over 75% of the energy mix. Nearly 15% of the existing coal power plant capacity was built prior to 1980 and will be 50 years or older by the year 2030. An additional 27% of capacity was built after 1990s and will be 40 years or older by 2030. Currently over 275 generating units are operating in India [7].

3. The importance of energy transition

In the 21st century, India faces twin challenges, one of expanding opportunities for a growing population and another of reducing import dependence of petroleum products. At the same time, carbon emission reduction is also a challenge. The need for transition to a green economy are given below.

3.1. The relevance of fuel poverty

Energy is essential for everyday living and to get work done. The quality of life depends on the quality and quantity of energy used. Generally, poor people use traditional fuels such as fuelwood, whose utilisation efficiencies are as low as 10%. These fuels for poor are inefficient, expensive (in terms of useful energy) and hazardous to health. The poor spend a far greater proportion of their income on energy (15–30%) than the wealthy (3–6%) [27]. Even as recently as 2012, nearly 75% of rural households and half of the urban households in India have used bio-fuels. It is an important consideration while examining the impacts of shifting to energy-efficient technologies and devices, which assist the fuel-poor through investments in these initiatives.

3.2. Worker intensity

In general, any investment in the economy will create jobs (direct and indirect) depending on the labour intensity in the sector. In the case of energy, traditional energy extraction and power generation are capital intensive [3]. The renewable energy as well as energy efficiency are labour intensive [5] which benefit countries like India which has the largest youth population in the world with around 66% of the total population under the age of 35. At present, a significant share of youth is either unemployed or employed with low salaries in informal sector [22]. Therefore, a shift to renewable energy system provides opportunities for this young people as they enter the labour market.

3.3. Reduction of energy dependence

Increased energy efficiency and the shift from non-renewables to renewables can contribute to sustainable development by stimulating economic growth [25]. Studies suggest that many countries with lower energy intensities (consumption per unit of economic output) show higher rates of economic growth than their competitors [24,29]. Also an economy which makes efficient use of resources will grow more rapidly than one which is wasting the resources through inefficient use. Also, since renewable are indigenous resources, they reduce import dependency thus providing energy security.

3.4. Environmental considerations

In general, environmental benefit is not a factor in consumer decisions in fuel choice. However, many low-carbon energy systems provide benefits in cost, productivity, and in the quality of service provided [30]. Hence, policy action is needed to accelerate energy transitions. If a decision to shift to a low-carbon energy system is based solely on environmental criteria, then policy action would be the only way to enact such a transition. Traditional approaches exploring transitions has not paid any attention to the interaction between technology and society and neglect the role of actors [31,32]. To rectify this we need new and innovative approaches keeping in mind the socio-economic-technical nature of the system that will assist policy makers to design strategies to achieve a green economy.

For the present study, we develop two contrasting scenarios that describe possible transitions towards a green economy. These scenarios—baseline and green economy—provide the changing energy mix under the current policy framework and a new policy paradigm, respectively. The BAU scenario reflects existing policies

Table 1
Energy demand (MTOE), GDP and carbon emissions (1960–2010).

Type of carrier	1960–61	1970–71	1980–81	1990–91	2000–01	2011–12
Coal[a]	35.7 (79.9)	37.3 (62.3)	58.2 (60.2)	97.7 (55.9)	138.0 (49.1)	283 (51.8)
Oil[a]	8.3 (18.6)	19.1 (32.0)	32.3 (33.4)	57.8 (33.1)	107.0 (38.1)	186 (34.1)
Natural gas[a]	0.0 (0.0)	0.6 (1.0)	1.41 (1.5)	11.5 (6.6)	25.1 (8.9)	48 (8.8)
Hydro[a]	0.7 (1.5)	2.2 (3.6)	4.0 (4.1)	6.2 (3.6)	6.4 (2.3)	12 (2.2)
Nuclear[a]	0.0 (0.0)	0.6 (1.1)	0.8 (0.8)	1.6 (0.9)	4.41 (1.6)	17 (3.1)
Total Commercial	42.8 (36.5)	60.3 (41.0)	99.8 (47.9)	181.1 (59.7)	296.1 (68.4)	546 (76.4)
Non-Commercial	74.4 (63.5)	86.7 (59.0)	108.5 (52.1)	122.1 (40.3)	136.7 (31.6)	169 (23.6)
Total	117.2	147.1	208.3	303.2	432.8	715
GDP/cap (US$)	220	250	295	400	590	1050
Energy consumption/cap (TOE)	0.267	0.268	0.305	0.358	0.420	0.591
Carbon emissions (tons/cap)[a]	0.07	0.1	0.14	0.22	0.31	0.45

[a] Boden et al., [11]; Source: [8].