Overview of Sustainable Energy in Central Europe and East Asia

Janda, Karel and Tan, Tianhao

9 February 2017

Overview of Sustainable Energy in Central Europe and East Asia[#]

Karel Janda[*] – Tianhao Tan[**]

Abstract. This paper starts with a brief literature review of sustainable energy literature with focus on economic aspects of sustainability. This is followed by description of energy situation in Central Europe and East Asia with a focus on sustainable energy resources. Our analysis of energy sector describes energy sector and both fossil and renewable fuel energy supply with particular emphasize on electricity.

Key words: Renewable Energy; Central Europe; East Asia

JEL classification: R11; Q42

[#] This project has received funding from the European Union's Horizon 2020 Research and Innovation Staff Exchange programme under the Marie Sklodowska-Curie grant agreement No 681228.We also acknowledge support from the Czech Science Foundation (grant 16-00027S) and from University of Economic, Prague (institutional support IP100040). Karel Janda acknowledges research support provided during his long-term visits at Australian National University and McGill University. The views expressed in the paper are those of the authors and not necessarily those of our institutions.

[*] Karel Janda; Department of Banking and Insurance, University of Economics, Prague, W. Churchilla 4, 13067 Praha 3, Czech Republic and Institute of Economic Studies, Charles University, Opletalova 26,11000 Praha 1, Czech Republic, E-mail: Karel-Janda@seznam.cz

[**] Tianhao Tan; Faculty of Social Sciences, Charles University, Opletalova 26,11000 Praha 1, Czech Republic, E-mail: tianhao.tan.14@ucl.ac.uk

1. Introduction

This paper starts with a brief literature review of sustainable energy literature with focus on economic aspects of sustainability. This is followed by description of energy situation in Central Europe and East Asia with a focus on sustainable energy resources. Our analysis of energy sector describes energy sector and both fossil and renewable fuel energy supply with particular emphasize on electricity.

2. Literature Review

Nowadays, awareness of increasing sustainable energy usage and proportion has been raised, a more definition about sustainable energy has been presented in (Brundtland Commission Report, 1987), which defines: 1) sufficient growth of energy supplies to meet human needs; 2) efficiency and conservation measures to minimise waste of primary resources; 3) addressing public health and safety, protect the biosphere and prevent more localized forms of pollution.

Over the past decades there has been a surge of international and domestic study into how the world economy has rapidly developed and energy requirements have increased remarkably, increasing the realization that sustainable energy must plays an important role. Examples of some practical literature reviews into performance and prospects study are Ibrahim D. (2000) and Michael J. (2006), in which points out how primary energy supplies and sustainable energy contributes to society, Roy L. Nersesian (2010) discussed about sustainable energy in the world future, clarifies complex technical issues, enlivens history, and illuminates the energy policy dilemmas we face today. More recently, Steven C. and Arun M. (2012) provides a scenario of the current energy landscape and discusses opportunities and pathways for sustainable energy that could lead to a prosperous, sustainable and secure energy future for the world. Seasonal and annual reports such as IEA World Energy Outlook (WEO) (2004, 2013)[1], IEA atlas statistics reports concerning Renewable Information (2015), CO_2 Emissions from Fossil Fuel Combustion (2015) and related Electricity Information (2015) reports give a closer look at related factors and data that link to energy current status in micro-aspect.

Paper works of Pablo del Rio and Mercedes Burguillo (2009) and Roland Wengenmayr & Thomas Bührke (2008) inspired many in empirical analysis on the impact of different sustainable sources towards local sustainability criteria particularly via case studies. Quantitative and qualitative approaches used in these researches to compare local impacts of

[1] *World Energy Outlook 2013, 2015*; IEA Statistics

renewable energy projects, proven that the contribution of sustainable energy source affected by the economic and social dimensions of factors just as significantly.

Increasing specific researches give a close look at: (i) Wind energy, e.g. Greenpeace and the Global Wind Energy Council (GWEC) (2008) and Bert J.M. de Vires et al. (2007), showing wind potential in 21st century at a global level. Wind energy is a top promising sustainable source and widely applied globally, a practical case study of wind power industry in a leading market would be necessary. This case study inspired by The Global Cleantech Innovation Index (2014), which depicts about world future and outlook in China's role; GWEO (2012, 2014) offers suggestions in choosing potential criterions for judgements and variables used in the study; Poul-Erisk M. and Shimon a. (2009) proposed costs, investment, technology for grid system and integration, and energy policy as the major risks during management for wind energy projects; (ii) For hydropower, Gary W.F. & Deborah M.L. (2002) defines what meant by "renewable" and "sustainable", and decision makers have to decide which particular technologies or organizations would be eligible for subsidies and tax or tariff concessions, which plays important role in costs of generating sustainable energy. Small-hydropower plants are not to be ignored; (iii) When it comes to solar energy, the literature of K.H. Solangi, et al. (2011) focus on solar energy policy and its influence towards global solar development. A more global and regional outlook given by REN21 Global Status report (2014); (iv) On the one hand, both Karin E. and Lars J.N (2006) and Matti P. (2004) dig into the potential of biomass. On the other hand, E.M. Kondilia and J.K. Kaldellis. (2007) studied biofuels implementation in Europe; (v) Geothermal, e.g. John W.L., Derek H.F., Tonya L.B. (2011), Enrico B. (2002) did research in geothermal utilization status; (vi) And nuclear resource, e.g. Aviel V. (2008).

Sustainable energy industry is a conglomeration of diverse categories environmental friendly resources, like Ibon Galarraga et al. (2011) mentioned, has evident relationship with economic growth in many ways: Noam L. and Na Z. (2009) showed how sustainable energy can improve environmental performance situation and then Noam Lior et al. (2010) discussed about current evidence shows sustainable sources are more efficient and safer energy supply, etc.

On the one hand, apart from empirical researches like Simona B. (2015) and Susan B. & Petr J. (2007), CE countries have implemented a variety of conferences or projects under rising

awareness of sustainable energy potentials, e.g. Central Europe Programme (2007-2013)[2] by supporting smart and sustainable growth through behavioral change, annual conferences in CE area for different time periods introducing dedicated Low Carbon Axis. According to programme records, CE economies majorly used biomass energy like *4BIOMASS project*[3] *(2008-2012)*, solar energy like *CEC5 project*[4] *(2011-2014)*, and geothermal projects like *TRANSENERGY project*[5] *(2010-2013)*, estimating energy use and carbon dioxide emissions for city districts, thus assisting regional policy makers to plan SE source efficiency improvements.

On the other hand, EA, which remains one of the main growth drivers of the world economy, accounting for nearly two-fifths of global economic growth, a great number of research papers like V. Thavasi & S. Ramakrishna (2009) and book Christopher M. Dent (2014) in both socio-economic and environmental perspectives. China, South Korea, Japan and Chinese Taiwan are the most important regions in East Asia as their economies have been growing steadily. These countries or regions though heavily dependent on fossil fuels have stepped up their measures towards low-carbon society amid domestic affordability challenges and changing global mindset. In addition, EA markets mostly applied wind, hydro, biomass and geothermal sources according to WB*: The East Asia Pacific projects and programme (2016)*[6]. Among those markets, People's Republic of China is the economy entity has fastest growth rate in many fields that cannot be ignored as IEA Renewable Information report (2015) put forward with, another important reference is Xiliang Z. et al. (2010).

3 Central European and South Asian Energy in Global Perspective

3.1 Energy global landscape and total primary energy supply

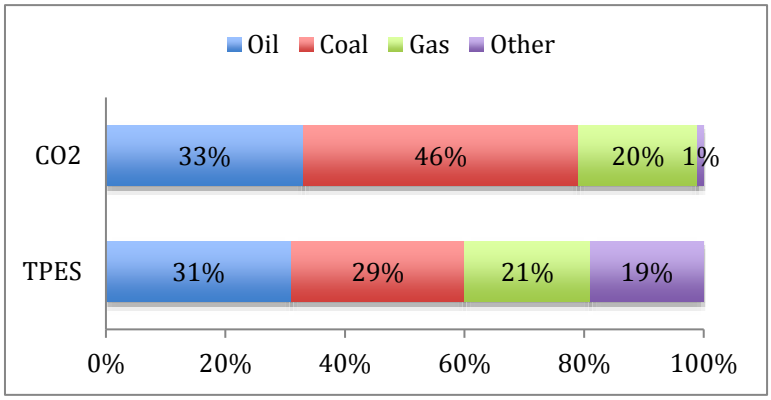
Broadly speaking, the current world energy system is highly dependent on fossil fuels, among them, in 2013 oil sources take up near one-third (31%) of world total primary energy supply (TPES), coal dropped down to the second major energy source with 29% followed by nature

[2] Central Europe programme: http://www.central2013.eu, some documents have been archived due to new period 2014-2020 begins.
[3] 4BIOMASS project: http://www.4biomass.eu/en/project
[4] CEC5 project: http://cec5.telesis.eu/index.html
[5] Transenergy geothermal project in Slovenia, Austria, Hungary and Slovakia: http://transenergy-eu.geologie.ac.at
[6] World Bank, projects and programs in East Asia and Pacific, http://www.worldbank.org/en/region/eap/projects

gas occupied 21% of TPES (4.1).

Figure 3.1

World Primary Energy Supply and CO_2 Emissions: Share by Fuel in 2013



Note: other hydro, tide, wind, includes nuclear, geothermal, solar, biofuels and waste.

Source: CO_2 emissions from fuel combustion, IEA statistics, 2015

Total fossil fuels combustion accounted for 84% of global greenhouse gas emissions in 2009, with defects in environment-friendly and climate-friendly way cannot be ignored.

From Figure 3.1 above, globally, coal combustion generates the largest share of CO2 emissions, although oil remains the largest energy source, Outstandingly, although coal represented 29% of the world TPES in 2013, which actually accounted for 46% of global CO_2 emissions due to its heavy carbon content per unit of energy released. In conclusion, primary fossil fuels energy contributed greatly to world economic development but also bring emission problems.

Table 3.1

Summary of CO2 emissions from fossil fuels in CE and EA countries, 2013

Million tones of CO2

Country \ Year	2000	2005	2010	2012	2013	% Change 2000-2013
Germany	812.40	786.80	759.00	744.90	759.60	(3.77)
Switzerland	41.90	43.90	43.10	40.50	41.50	(0.03)
Czech Republic	121.30	118.50	111.40	105.60	101.10	(1.44)
Poland	289.70	296.30	310.40	296.80	292.40	0.19
Hungary	53.30	54.70	47.50	42.10	39.50	(0.99)

Austria	61.70	75.10	69.70	65.20	65.10	0.24
Slovak Republic	36.90	37.30	34.60	31.20	32.40	(0.32)
Slovenia	14.10	15.40	15.40	14.90	14.30	0.01
China	3299.70	5401.00	7137.30	8564.30	9023.10	408.81
Chinese Taiwan	214.30	253.60	256.20	246.60	248.70	2.46
Japan	1156.60	1196.10	1126.10	1217.20	1235.10	5.61
South Korea	431.70	457.50	550.80	575.30	572.20	10.04
World	23321.60	27047.60	29838.20	31490.50	32189.70	633.44
CE avg.	178.91	178.50	173.89	167.65	168.24	(0.76)
EA avg.	1275.58	1827.05	2267.60	2650.85	2769.78	106.73
EA avg. without China	600.87	635.73	644.37	679.70	685.33	6.03

Source: CO_2 emissions from fuel combustion, IEA statistics, 2015

Obviously, global CO2 emissions from fossil fuels level has experienced a great expansion which with 633.44% change during periods 2000-2013, among all markets, largely contributed to China's outstanding development represented by 408.81%, for the average change rate in other EA countries, it stands only 6.03% in CO2 emissions from fossil fuels. Divergently, CE countries had a slight decrease 0.76% at the same period.

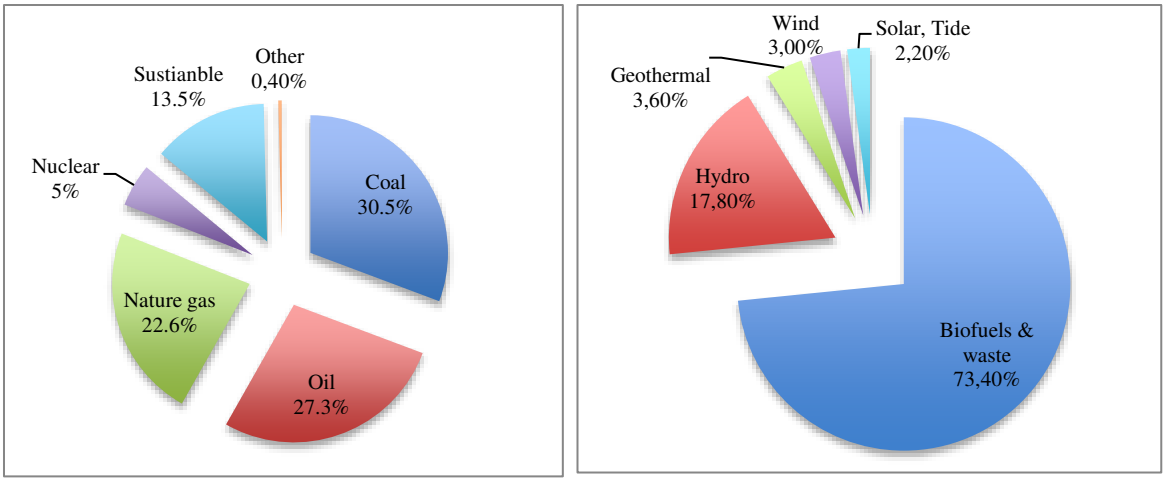
And in 2013, world TPES was 13,555 million tones in oil equivalent (Mtoe) of which 13.5%, or 1,829 Mtoe, 13.5% (18.5% if include nuclear energy sources) of them was produced from sustainable energy sources[7], coal, oil and nature gas are still the mainly used primary energy, as Figure 3.2&3.3 shows below.

Figure 3.2 2013 Fuel Shares in World TPES[8] *Figure 3.3 2013 Shares of SE in World Supply[9]*

[7] *Renewable Information*, IEA statistics 2015

[8] Figure 4.2 Excludes pump storage generation

[9] Figure 4.3 Other transformation, energy industry own use, losses; Includes the agriculture/ forestry, fishing and non-specified industries, Rounding



Note: Totals in graphs might not add up due to rounding.

According to some studies, in most parts of the world, first of all, economic activity remains the principal driver of demand for energy and is therefore strongly correlated with carbon emissions. More than five years after the severe recession began in 2008, global economic recovery continues to be fragile and uneven during 2004-2013 periods, which lead to relative drastic change in global energy structure. Secondly, demographic factors will continue to drive changes in the energy transformation and drive purse for sustainable energy in worldwide. Besides, the world is experiencing a period of historically high oil prices[10], yet big differences remain between nature gas prices in regional markets, and coal prices remain much lower than others' prices in energy equivalent terms, indicates that the expansion of sustainable energy sources subject to a costs and prices reduction.

Due to its widespread non-commercial use (e.g. residential heating and cooking) in emerging markets, especially in Asia, biofuels (including wastes) is by far the largest sustainable energy source, representing 10.4% of world TPES (not presented) and 73.4% of global sustainable energy supply (Figure 3.3 above). The second largest sustainable energy source is hydropower, which provides 2.5% of world TPES (not presented) and 17.8% of renewables. Geothermal, biofuels, solar, wind, and tide each hold a smaller share and make up the rest of the sustainable energy supply.

Global demand for energy is rapidly increasing, because of population and economic growth, especially in large emerging market economies, which will account for 90% of energy demand growth to 2035. While accompanied by greater prosperity, riding demand creates new challenges. Energy security concerns can emerge, as more consumers require ever more

[10] *World Energy Outlook (WEO) 2013,* IEA

energy resources, and higher contribute to global warming. At the same time, the number of people without access to electricity remains unacceptably high.

3.2 Electricity generation outlook

Generation of electricity (the capital in investment plus operating and fuel costs) normally makes up about one-half of the delivered cost of electricity.

Unlike fossil fuels energy, there is no way to store electricity (batteries are incapable of storing the amount of electricity required to support the operations of utility), which means requires “energy to create energy”.

Figure 3.4

Total Electricity Generation (TWh) landscape in 2004

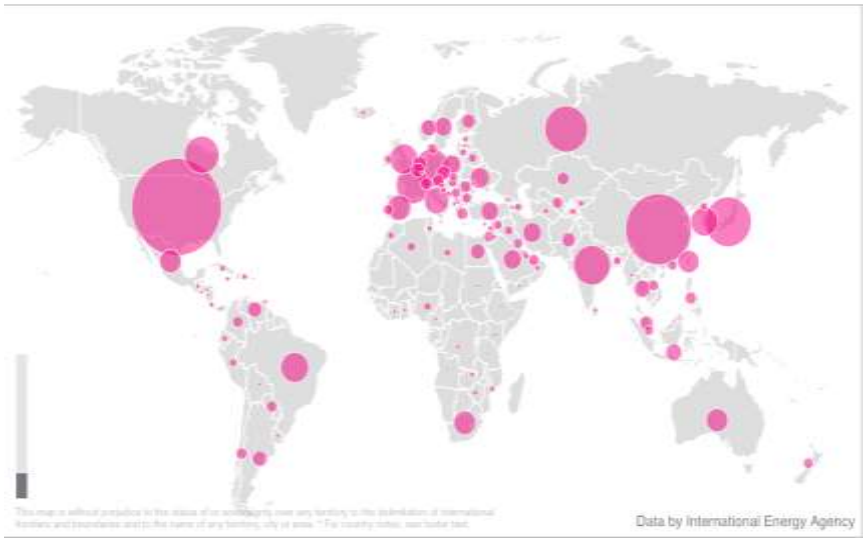


Figure 3.5

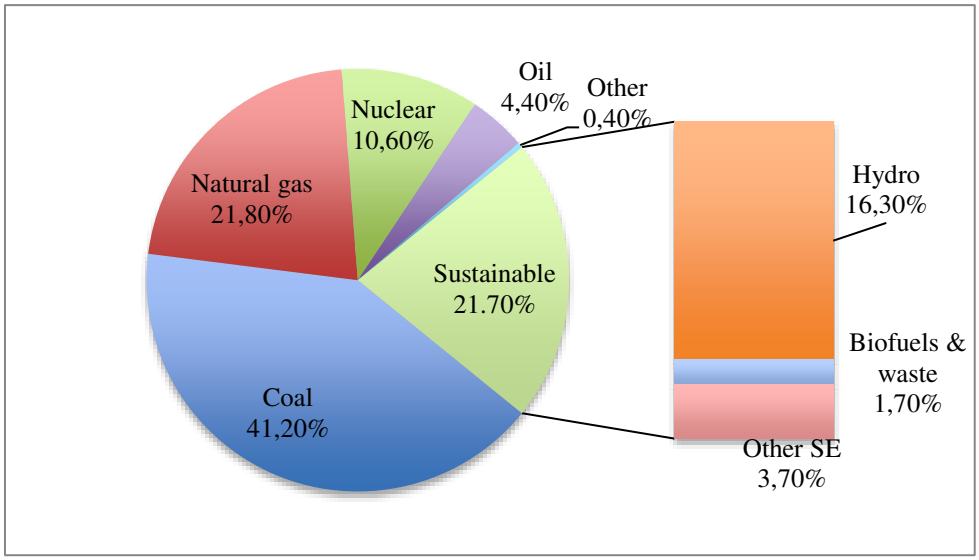
Total electricity generation (TWh) landscape in 2013

Source: IEA Electricity Atlas, world map, 2013

These two landscape figures tell us Central Europe is one of the most intensive areas of electricity generating, followed by the US and East Asia, China, the quickest runner with dramatic generation of electricity in 2004-2013 periods.

Figure 3.6

Fuel shares in world electricity production, 2013



Source: World electricity production sources, IEA statistics, 2013

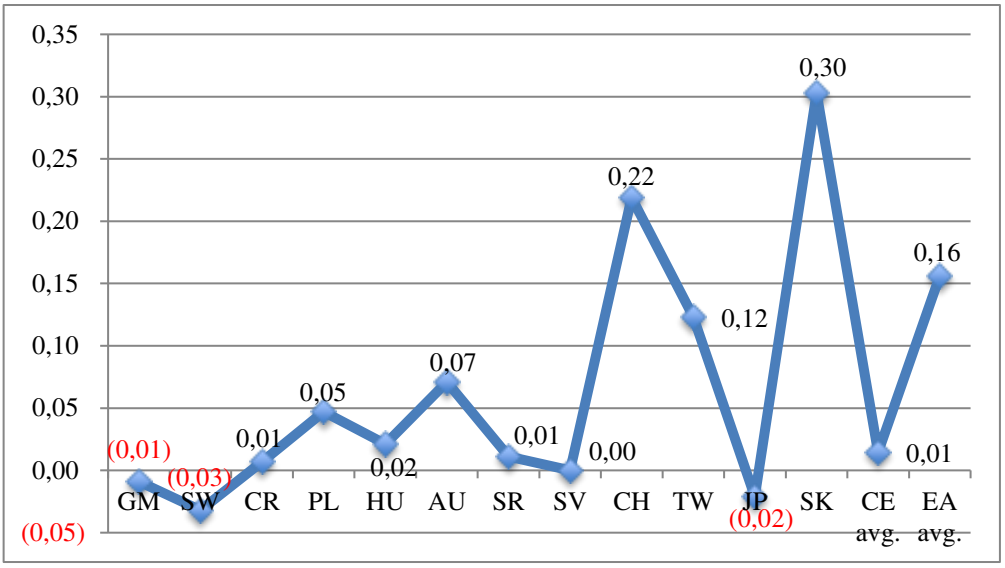
Notes: 1. Includes electricity from energy sources not defined above such as non-renewable wastes, peat, oil shale, and chemical heat; 2. Includes geothermal, wind, solar, tide.

An in-depth focus on correlation between electricity consumption level across countries is presented in Figure 3.7[11] downwards, energy is essential for electricity generation and so that critical for worldwide economic development, those CE and EA countries' growing energy consumption and its average figure (see CE avg. and EA avg. respectively) also has broad implications for the regional and global energy outlook.

Figure 3.7

Change of electricity consumption per capita (MWh/capita), 2004-2013

[11] GM: Germany; SW: Switzerland; CR: Czech Republic; PL: Poland; HU: Hungary; AU: Austria; SR: Slovak Republic; SV: Slovenia; CH: People's Rep. of China; TW: Chinese Taiwan; JP: Japan; SK: South Korea



Source: IEA Energy Atlas, electricity statistics, 2013

Negative figures found in Germany, Czech Republic and Japan in change of electricity consumption per capita (MWh/capita) indicates a slight decline in those 3 countries from 2004 to 2013. Basically due to the impact from the great global economic recession in 2008, and which caused the major decline only in the following year, Germany dropped from 7.19 to 6.

82, Switzerland experienced a smoother decline from 6.46 to 6.11, similar trend found in Japan from 8.05 to 7.81 (Appendix 1).

At the meantime, rising stars South Korea and China in EA markets experienced the greatest change with 0.3%, 022% respectively, which leads to higher average annual increase rate of electricity consumption per capita in EA at 0.16%, in comparison, CE avg. only at 0.01%. The electricity consumption in each CE counties has experienced only minor change. It is worth mentioning that nuclear electricity production increased in 2013 slightly after the accident at the Fukushima plant in Japan in 2011. However, Japan nuclear electricity production reached zero in October 2013 and, as of publication, no nuclear plant started operation under new regulations.

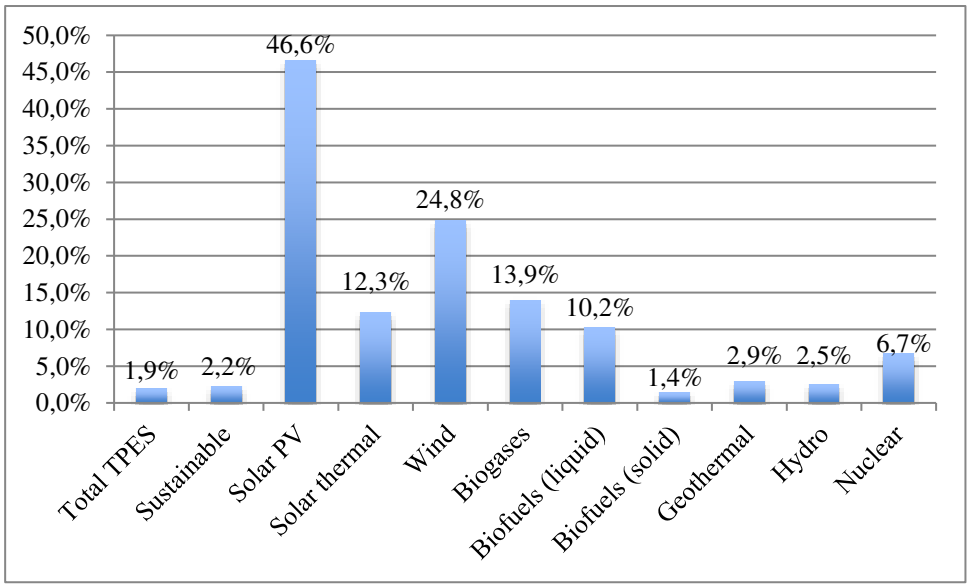
In a word, the increasing total world electricity production and consumption reflects the positive economic growth trend, which has prevailed since 2004, although with divergence in countries. In 2013, 67.2% of world electricity production was from fossil fuel-powered plants. Hydropower provided 16.6%, nuclear 10.6%, biofuels and waste 2.0%, and geothermal, solar, wind and other SE sources made up the remainder.

3.3 Sustainable energy outlook

As Section 3.1 mentioned, economic activity has proved a strong relationship with energy consumption. However, a noticeable shift occurred after 2004 – 2013 periods and in 2014, with emissions failing to increase despite a 3.3% expansion of the global economy[12] (not presented). This development can be largely attributed to changing patterns of energy consumption in China and OECD countries[13].

Figure 3.8

Annual growth rates of world sustainable supply from 1990 to 2013



Source: Renewables Information (2015 edition), IEA Statistics

The difference in Figure 3.8 presents different energy category has experienced during 1990-2013 periods, leading by total solar power at 58.9%, including solar PV at 46.6% and solar thermal at 12.3%. Followed by total biomass source at 25.5% (at which liquid and solid biofuels accounts for 10.2% and 1.4% respectively, biogases accounts for 13.9%) and similar wind power at 24.8%. Divergence can be attributed to the slow growth of hydroelectric power, with average annual growth of only 2.5%, only slightly higher than the 0.3% growth rate of total TPES over the period (Figure 3.8). Because hydroelectric capacity is mature in

[12] WEO 2015, Chapter 1. Introduction and scope, Figure 1.2 Energy-related CO2 emissions and economic growth, 2005-2014

[13] *World Energy Outlook 2015*, IEA - "In China, 2014 saw greater generation of electricity from renewable sources, such as hydropower, solar and wind, and less burning of coal, alongside a shift in the structure of economic output from energy-intensive industries towards the services sector. In OECD economies, recent efforts to promote more sustainable growth – including greater energy efficiency and more renewable energy – are producing the desired effect of decoupling economic growth from greenhouse-gas emissions."

most CE member states with only 0.7% growth rate, it is increasingly difficult to locate suitable environmentally acceptable sites to expand this energy form, although in 2013, EA countries' share of hydro reached significant achievement, and further increase is likely to be from these countries, as most of the remaining hydro potential resides in these countries. Therefore, new growth is to be expected for this sector. Nuclear power and geothermal energy also grew slower than total renewables, at 1.4% and 2.9% per annum since 1990.

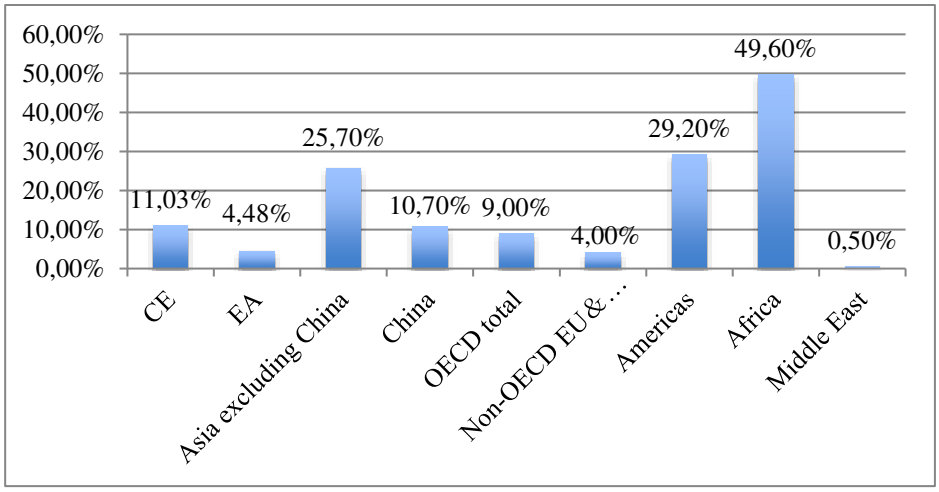
Over the last 40 years, the contribution of sustainable energy to TPES had more or less been stable around 12.5%. Although solid biofuels (mainly fuel wood) are by far the largest SE source, representing three quarters of global sustainable sources supply, recent dramatic developments in solar and wind due to supporting policies have started to change the energy renewables mix, especially for specific territories in CE and EA.

The steep growth of solar and wind compensated the decline in share of hydroelectricity, and therefore sustainable energy have kept their rank of third largest contributor to global electricity production. They accounted for 21.6% of world generation in 2013, after coal (41.2%) and slightly behind gas (21.8%), but ahead of nuclear (10.6%) and oil (4.4%). However, for some countries the share can be much higher, and in fact equal or close to 100%.

The electricity price module in the Cost of Electricity Generation model (Section 2. Methodology remarks, Eq. (2)) has been revised to better represent the cost elements of the power system, from generation costs (including incorporating more complete information for all regions on historical investment costs), to the costs 16 associated with transmission and distribution, and subsidies for primary fossil fuel energies, electricity and sustainable energy technologies.

Figure 3.9

Shares of sustainable energy of regional total primary energy supply in 2013



Source: Renewables Information (2015 edition), IEA Statistics[14];

Consequently, in Middle East countries the share of sustainable energy in TPES is only 0.5% compared to 49.6% in Africa, 25.7% in Asia area and nearly half of the pre cent contributed by EA markets (4.48%), among which China accounts for 10.7% (Figure 3.9), Central Europe is 11.03%. However, although the East Asia area only occupies 4.48% similar to Non-OECD Europe and Eurasia at 4%, it countries play a major role when looking at "new" sustainable energy, supplying one-third of world energy from hydropower, wind, solar, sustainable municipal waste and biomass energy in 2013.

This paper highlights the sustainable energies' production and their contributions to energy sector majorly displaying by contributions to electricity generation, including several comparison with primary fossil fuel energy consumption. And the challenges faced by energy producers and users; how they can be addressed using sustainable energy growth policies underlines the global economy.

But such challenges also create opportunities. A sustainable future will require essentially a new transformation in the way we produce, deliver and consume energy. The market's goal is to provide access to modern energy services, higher efficiency in energy usage, protect global environment to ensure reliable energy supplies and green growth. Aiming to develop SE is first and foremost for energy sector about implementing changes and achieving common purpose: a world that is stronger, cleaner, and fairer. In addition, WEO-2012 report found that even though there is increasing renewed policies focus on sustainable energy sources and its functioning efficiency, while key steps that would need to be taken to overcome country regulation system, preference and other barriers, and thereby allow the market to realise the

[14] CE and EA statistics are measured from IEA Statistics Atlas, 2013

potential of sustainable energy outstanding efficiency in which way transfer into more energy-economical society, details in Table 3.2.

Table 3.2

Recent progress & key conditions for faster deployment of SE technologies

Technology	Recent Progress	Key Conditions
Renewable power	Investment fell by 11 in 2012 from 2011 due to tougher financing conditions, policy uncertainty and falling technology costs. Solar PV capacity still grew by 42 and wind by 19, compared with 2011 cumulative levels.	Ongoing subsidies (as renewables generally remain more expensive than other sources of power). Reforms to facilitate grid integration. Increased RDD in emerging technologies, such as concentrating solar power, ocean and enhanced geothermal.
Nuclear power	Seven projects started construction in 2012, an increase from 2011 when new projects fell to only four after the Fukushima Daiichi accident. In 2010 there were 16 new projects.	More favourable electricity market mechanisms and investment conditions to reduce risk and allow investors to recover high upfront capital costs. Quick implementation of post-Fukushima safety upgrades to foster public confidence.
Carbon capture & storage (CCS)	13 large-scale CCS demonstration projects are in operation or under construction. Construction began on two new integrated projects in 2012, while eight projects were cancelled.	Financial and policy commitment by governments to accelerate demonstration efforts. Sufficiently high price on CO_2 emissions or a commercial market for captured CO_2 for enhanced oil recovery.

Biofuels	New investment was 50 lower in 2012 than in 2011, as a result of over- capacity, and a review of biofuels support policies and higher feedstock prices.	A longer-term policy framework to build investor confidence. RDD to improve cost and efficiency, and to develop sustainable feedstock. Development and application of internationally agreed sustainability criteria and standards
Energy efficiency	Evidence of renewed focus from governments, with many major energy- consuming countries announcing new measures.	Policy action to remove the barriers obstructing the implementation of energy efficiency measures that are economically viable

Sources: IEA (2013c and 2013d).

Those policies scenarios include: (i) increasing renewable power investment (ii) promoting nuclear energy projects (iii) introducing new integrated projects on carbon capture & storage (iv) creating long-term biofuels framework and (v) removing barriers across countries in energy efficiency. Successive ongoing improvements in energy efficiency by adopting a portfolio of existing and new SE technologies addressed the challenges posed by world's rising fossil fuels energy use.

Although an IEA review concluded that recent progress in developing and deploying sustainable energy technologies and in improving energy efficiency has so far not been sufficient to achieve announced policy objectives and is being limited by market failures[15]. But it saw some reasons for optimism. For example, annual sales of hybrid vehicles in 2012 passed the 1 million mark for the first time and solar photovoltaic (PV) systems and wind turbines were installed at a rapid pace by historical standards

3.4 Description of sustainable energy supply in CE and EA markets

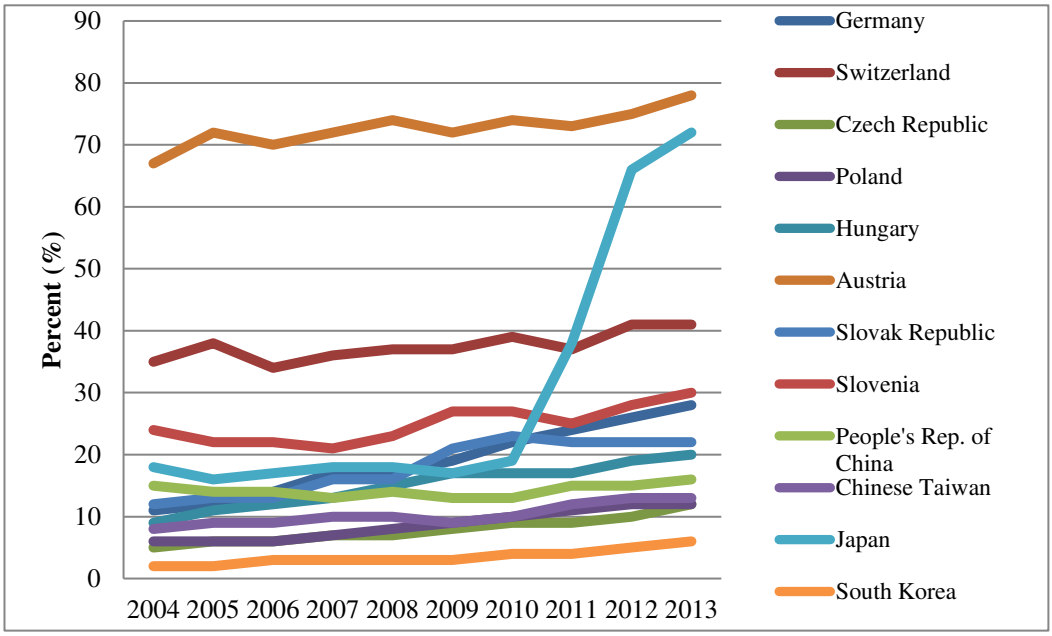
According to published documents, science and technology are the driving force for innovation and development for SE. Energy policy, country legislation and system, home market size and maturity, and investment & funding mechanisms have to work together to

[15] *WEO-2013c*, released in mid-2013, IEA

develop SE that address the energy needs. Numerous technologies have to be developed for implementing and integrating SE such as wind, hydropower, biomass, solar and tidal power, nuclear power and geothermal source to meet up with the enormous energy demands currently as well as in future.

Figure 3.10

Share of SE to total energy production in CE and EA countries (Mtoe)



Source: IEA (2016), Energy Indicators (2013)

In Figure 3.10 above, a current sustainable energy scenario is baselines in which all categories of sustainable energies are formally adopted and implemented are taken into account. Under these scenarios, the broad energy trends are:

a) Generally for all countries, shares of sustainable energy to total energy production are rising, in spite of divergent growth rate, all have positive growth rate. Except for great change in Japan (5.4%), followed by Germany (1.7%), other countries only had little changes.

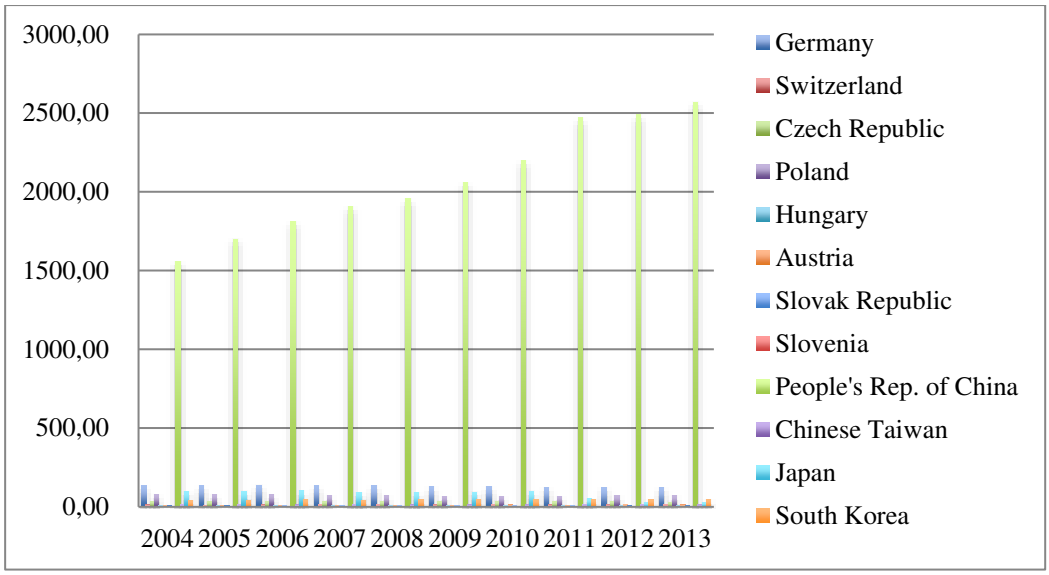
b) Among 12 countries in CE and EA areas, Austria and Switzerland are the leading runners, with average levels in SE share to total energy production at 72.5% and 37.5% respectively; Japan caught up with drastic growth rate since 2010, increased from 19% to 72% from 2010 to 2013, who has greatest change rate at 5.4% at periods 2004-2013.

c) Although average rate of SE proportion rate in CE are much higher than EA countries at the beginning (Appendix 2), CE avg. stands for 21.13% in 2004 and EA avg. stands for near only half of CE's, at 10.75% at the same time. However, EA countries quickly catch

up to similar levels in 2013, especially thanks to technical breakthrough lead to great contribution in 2011 (increased form 11.5% to 17.25% in one year).

Figure 3.11

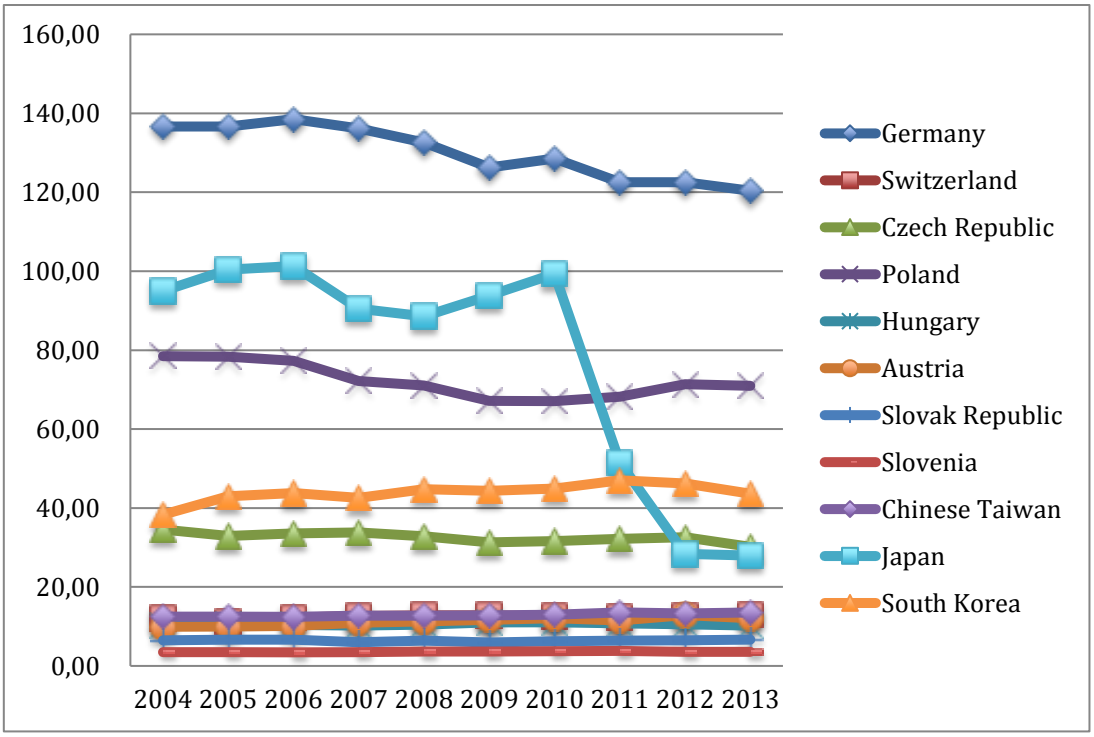
Status of Sustainable Energy total production in CE and EA countries (Mtoe)



Source: IEA (2016), Renewables Energy Indicators (2013)

Figure 3.12

Status of Sustainable Energy Total Production in EA and CE countries, excluding China (Mtoe)



Despite of the share of sustainable energy in total energy production differ across all countries, as those two figures above shows; China is definitely the No.1 in SE production (Figure 3.11). Besides, their absolute sustainable energy production numbers have dropped in several countries (Germany, Japan) and barely had any changes in other countries (Figure 3.12). That is, status of SES development in CE and EA countries still facing with difficulties (analysed and presented in next chapter Section 5).

Table 3.4 below gives detailed status situation in each market from 2004 to 2012, CE countries seems like have promoted their SE development more successfully with higher average annual growth rate from 2004 at 18.97% at the beginning to 28.93% in 2012. In comparison, EA countries had little change from 7.13% to 8.98% in the same period. Reasons for such divergences can largely contribute to technology levels and home market maturity of SE.

Table 3.3

Share of SE to total energy production across CE and EA countries, 2004-2013

Renewable electricity output (% of total electricity output)

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012
Germany	9.17	10.06	11.24	13.85	14.63	16.02	16.66	20.33	22.93

Switzerland	29.20	30.09	51.73	54.90	55.68	55.54	56.71	54.07	59.48
Czech Republic	3.27	3.82	4.21	3.89	4.49	5.70	6.92	8.34	9.29
Poland	2.02	2.48	2.67	3.42	4.27	5.74	6.93	8.05	10.44
Hungary	2.78	5.23	4.16	4.71	5.89	8.06	8.08	7.53	7.65
Austria	64.20	63.39	66.00	69.22	69.25	71.15	66.22	65.65	74.54
Slovak Republic	13.55	14.91	15.37	17.69	15.87	18.95	21.63	17.67	19.32
Slovenia	27.60	23.65	24.50	22.46	26.27	29.91	29.19	24.37	27.81
China	14.75	14.84	14.43	14.25	16.56	16.73	17.62	16.02	19.13
Chinese Taiwan	1.77	2.18	2.21	2.39	2.44	2.36	2.51	2.60	3.44
Japan	10.75	9.33	10.36	8.99	9.60	9.96	11.24	12.26	12.00
South Korea	1.26	1.04	1.00	1.07	0.99	1.04	1.25	1.44	1.34
CE avg.	18.97	19.20	22.49	23.77	24.54	26.38	26.54	25.75	28.93
EA avg.	7.13	6.85	7.00	6.68	7.40	7.52	8.16	8.08	8.98

Source: IEA Renewable Statistics (2013) *http://energyatlas.iea.org/?subject=-1076250891*

In the matter of fact, worldwide electricity generation increased dramatically from previous years to 2013, world gross electricity production increased from 6,144 TWh to 23,391 TWh, an average annual growth rate of 3.4%. Compared to the 22,740 TWh produced in 2012, global power production in 2013 increased (2.9%) for a fourth year in a row after the economic crisis in OECD countries led to a visible decline in global production in 2008 and 2009. In 2013, although TPES still play a major role, see 67.2% of world electricity production was from fossil fuel-powered plants, sustainable energy is regard as a promising future. In the same period, hydroelectric plants provided 16.6% of electricity generation, 10.6% from nuclear plants, 2% from biofuels and waste, geothermal, solar, wind and other sources made up the remainder[16].

Among the 12 country samples in this paper, namely the People's Republic of China (23%)

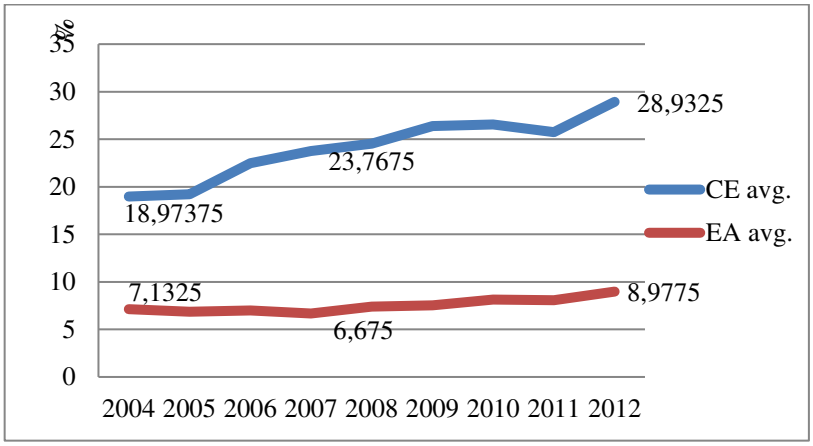
[16] IEA statistics, ELECTRICITY INFORMATION (2015 edition)

dominates the electricity production and also in the world. They are followed by Japan, Germany and South Korea. The top four countries account for more than half of global electricity production. Figure 4.6 below displays average trends of sustainable energy electricity generation output in CE and EA countries.

Figure 4.13 shows total CE countries generating electricity capacity increased at an average annual growth rate of 52.49% (climbed from 18.97375 to 28.9325) from 2004 to 2012, with capacity in other energy such as wind power, hydroelectric, solar and combustible fuel increased largely (not presented). By comparison, in EA countries at the same period total average sustainable energy electricity generating capacity increased at an average annual rate nearly half of CE's growth rate at 25.87%, increased from 7.1325 to 8.9775. In this period there also witnessed a remarkable growth in substantial additions of nuclear and geothermal capacity, as although many countries began to invest in sustainable energy resources, given the introduction, expansion or phase-out of nuclear power.

Figure 3.13

Sustainable energy electricity output share of total[17]



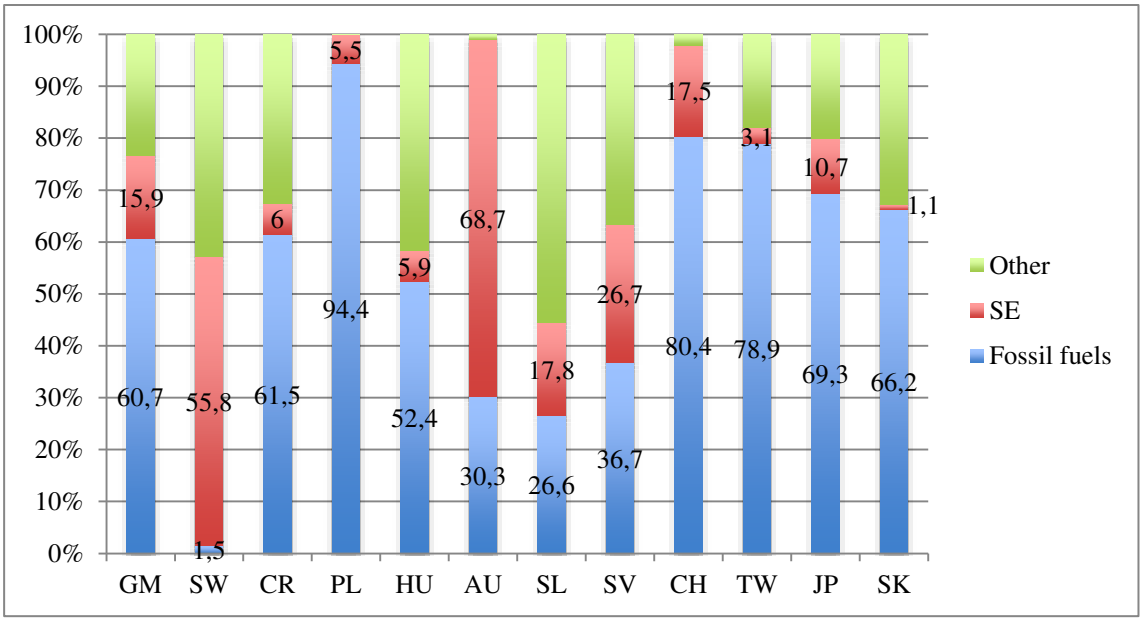
Source: IEA statistics, Energy Atlas 2012, Electricity[18]

Figure 3.14

Share of SE and fossil fuels energy in electricity production (%), respectively

[17] Notes: 1. Source: WB statistics, OECD/IEA 2013 edition (http://data.worldbank.org/indicator/EG.ELC.RNEW.ZS); 2. Chinese Taiwan source: Energy Statistical Data Book, P149 Net Electricity Produced & Purchased of Taiwan Power Company (2), BUREAU OF ENERGY, MOEA 2015

[18] IEA statistics, Energy Atlas 2012, Electricity: http://energyatlas.iea.org/?subject=-1118783123



Source: IEA Electricity statistics, 2013

Figure 3.14 above displays energy structure briefly across countries, portions of sustainable energy and primary fossil fuels energy source in each CE and EA country have been clearly stated respectively.

4 Conclusions

In general, fossil fuels energy are still the major source used in CE and EA countries, while the contrast phenomenon exist in Switzerland (55.8% in sustainable energy and only 1.5％ in primary fossil fuels energy), Poland particularly rely on primary fossil fuels energy as its share to total energy production accounts for 94.4%, only 5.5% for sustainable energy. Secondly, country and global energy policies and a variety of electricity sector and energy indicators, energy sector, and major changes in SE development are expected to occur not only in CE and EA countries, but also globally. Which also means non-fossil fuel energy will also face significant changes in the coming years.

According to an outlook about energy trends from OPEC, between 2013 and 2040, nuclear energy will increase at 2.2% p.a., making up 5.9% of the world's total energy consumption by 2040 averagely. The share of hydro and biomass, though growing, will remain relatively stable (hydro at around 2.5% and biomass within a narrow range of 9.5–9.8%). Other SEs, mainly wind and solar, are expected to grow at the fastest rates, multiplying their contribution to total primary energy supply by more than seven times. Their overall share will nevertheless

remain low, reaching around 4% in 2040.

Bibliography

[1] World Commission on Environment and Development. (1987) Report of the World Commission on Environment and Development: Our Common Future. Available online from http://www.un-documents.net/wced-ocf.htm. Oxford: Oxford University Press

[2] Ibrahim D. (2000) Renewable energy and sustainable development: a crucial review. Renewable and Sustainable Energy Reviews, 4(2), p.157-175

[3] Michael J. (2006) Sustainable energy development: performance and prospects. Renewable Energy, 31(5), p.571-582

[4] Roy, L. N. (2010) Energy for the 21st Century: A Comprehensive Guide to Conventional and Alternative Sources. 2nd ed. New York: M.E. Sharpe, Inc.

[5] Steven C. and Arun M. (2012) Opportunities and challenges for a sustainable energy future. Nature, VOL488, p.294–303 (16 August 2012), doi:10.1038/nature11475

[6] OECD/International Energy Agency (IEA). (2013) World Energy Outlook (WEO-2013). http://www.iea.org/newsroomandevents/pressreleases/2013/november/weo-2013-light-tight-oil-doesnt-diminish-importance-of-mideast-supply.html [Released on 12 November 2013]

[7] OECD/IEA. 2004. World Energy Outlook (WEO-2004). http://www.worldenergyoutlook.org/media/weowebsite/2008-1994/WEO2004.pdf [Released on December 2004]

[8] OECD/IEA. (2015) Renewables Information. ISBN PRINT 978-92-64-23886-2 / PDF 978-92-64-23887-9

[9] OECD/IEA. (2015) CO2 Emissions from Fossil Fuel Combustion. Available online from http://www.iea.org/publications/freepublications/publication/CO2EmissionsFromFuelCombustionHighlights2015.pdf [Released on November 2015]

[10] OECD/IEA. (2015) Electricity Information. ISBN PRINT 978-92-64-23888-6 / PDF 978-92-64-23889-3

[11] IEA. (2015) Special Data Release With Revisions for People's Republic of China. Available online from https://www.iea.org/publications/freepublications/publication/SpecialdatareleasewithrevisionsforPeoplesRepublicofChina04.11.2015.pdf [Released on 04 November 2015]

[12] OECD. Mapping Channels to Mobilize Institutional Investment in Sustainable Energy. Available online from http://www.keepeek.com/Digital-Asset-Management/oecd/environment/mapping-channels-to-mobilise-institutional-investment-in-sustainable-energy_9789264224582-en#page1. In series of Green Finance and Investment (Published on 09 February, 2015)

[13] Pablo del R. and Burguillo M. (2009) An empirical analysis of the impact of renewable energy deployment on local sustainability. Renewable and Sustainable Energy Reviews, 13 (6-7), p.1314–1325

[14] Roland W. and Thomas B. (2011) Renewable Energy: Sustainable Energy Concepts for the Future Sustainable energy development. ISBN: 3527657037. Germany: John Wiley & Sons Press

[15] Global Wind Energy Council (GWEC). (2012 edition) Global Wind Energy Outlook. Available online from http://www.gwec.net/wp-content/uploads/2012/11/GWEO_2012_lowRes.pdf (Accessed on November 2012)

[16] Derya E. and Frances R.H. (2015) How does uncertainty in renewable energy policy affect decisions to invest in wind energy? The Electricity Journal. Available online from http://www.sciencedirect.com/science/article/pii/S1040619015300026

(Available on 19 April 2016)

[17] BJM. de Vries., Detlef P. V., Monique M. H. (2007) Renewable energy sources: Their global potential for the first-half of the 21st century at a global level: An integrated approach. Energy Policy, 35(4), p.2590–2610

[18] Poul-Erisk M., Shimon a., and Soren K. (2009) The economics of wind energy: A report by the European Wind Energy Association. Denmark: EMEA

[19] Dr Himani G, M.V. S. Harshith, V. Shireesha, N. Alekhya. (2014) Bibliography on the Electrical Aspects of Small Hydro Power Plants. International Journal on Recent and Innovation Trends in Computing and Communication, 2(8), p. 2399-2404

[20] China Intellectual Property Right Net: www.CNIPR.com. Patent Information Search Platform: www.en-cnipr.com. Legal wind energy patents. (Data released on 30 December 2014)

[21] IFC World Bank Group. (2015) Hydroelectric power: A guide for developers and investors. Available online from http://www.ifc.org/wps/wcm/connect/06b2df8047420bb4a4f7ec57143498e5/Hydropower_Report.pdf?MOD=AJPERES (Accessed on February 2015)

[22] The Union of Electricity Industry (ELECTRIC). (2015) Hydro in Europe: Powering Renewables (Online) http://www.eurelectric.org/media/26440/hydro_report_final_110926_01-2011-160-0005-01-e.pdf (Accessed on September 2011)

[23] Gary W.F. and Deborah M.L. (2002) Hydro Hydropower as a renewable and sustainable energy resource meeting global energy challenges in a reasonable way. Energy Policy, 30(14) p.1261-1265

[24] Liu, H., Masera, D. and Esser, L., eds. (2013) World Small Hydropower Development Report 2013. United Nations Industrial Development Organization; International Center on Small Hydro Power. Available online from www.smallhydroworld.org

[25] OECD/IEA. (2014) Technology roadmap: Solar thermal electricity. (Online) https://www.iea.org/publications/freepublications/publication/technologyroadmapsolarthermalelectricity_2014edition.pdf (released on September 2014)

[26] K.H. Solangi, M.R. Islam, R. Saidur, N.A. Rahim, H. Fayaz. (2011) A review on global solar energy policy. Renewable and Sustainable Energy Reviews, 15(4), p.2149-2163

[27] Renewable Energy Policy Network for the 21st Century (REN21). (2014) Renewables 2014 Global Status Report. Available online from

http://www.ren21.net/Portals/0/documents/Resources/GSR/2014/GSR2014_full%20report_low%20res.pdf

[28] Karin E. and Lars J.N. (2006) Assessment of the potential biomass supply in Europe using a resource-focused approach. Biomass and Bioenergy, 30(1), p.1-15

[29] Matti P. (2004) Global biomass fuel resources. Biomass and Bioenergy, 27(6), p.613-620

[30] M. Fatih Demirbas, Mustafa B., and Havva B. (2009) Potential contribution of biomass to the sustainable energy development. Energy Conversion and Management, 50(7), p.1746–1760

[31] E.M. Kondilia and J.K. Kaldellis. (2007) Biofuel implementation in East Europe: Current status and future prospects. Renewable and Sustainable Energy Reviews, 11 (9), p.2137–2151

[32] Enrico B. (2002) Geothermal energy technology and current status: an overview. Renewable and Sustainable Energy Reviews, 6(1-2), p.3-65

[33] Ingvar B.F. (2001) Geothermal energy for the benefit of the people. Renewable and Sustainable Energy Reviews, 5(3), p.299-312

[34] John W. L., Derek H. F., Tonya L. B. (2011) Direct Utilization of Geothermal Energy 2010 Worldwide Review. Geothermics, 40(3), p.159-180

[35] Aviel V. Renewable and nuclear power: A common future? Energy Policy, 36 (11), p.4036–4047

[36] Ibon G., Mikel G.E., and Anil M. (2011) Handbook of Sustainable Energy. UK: Edward Elgar Publishing. Inc.

[37] Noam L. (2010) Sustainable energy development: The present (2009) situation and possible paths to the future. Energy, 35(10), p.3976-3994

[38] Simona B., Carlo A. B., and Silvia M. (2015) The Sustainability of Renewable Energy in Europe. Switzerland: Springer International

[39] V. Thavasi and S. Ramakrishna. (2009) Asia energy mixes from socio-economic and environmental perspectives. Energy Policy, 37(11), p.4240–4250

[40] Gale A.B. and Joseph X.P. (2000) Estimating the linkage between energy efficiency and productivity. Energy Policy, 28(5), p.289-296

[41] Piet G.M.B. (2006) Actual interaction effects between policy measures for energy efficiency—A qualitative matrix method and quantitative simulation results for households. Energy, 31(14), p.2848-2873

[42] Susan B. and Petr J. (2007) Dilemmas of transition: The environment, democracy and economic reform in East Central Europe - an introduction. Environmental Politics, ISSN: 0964-4016 (Print) 1743-8934 (Available online from http://dx.doi.org/10.1080/09644019808414370)

[43] James M. (2009) What about the politics? Sustainable development, transition management, and long term energy transitions. Policy Sciences, 34(4), p.323-340

[44] Christopher M. D. (2014). Renewable Energy in East Asia: Towards a new developmentalism. ISBN: 978-1-315-75119-1. 1st ed. Abingdon and New York: Routledge

[45] Z. Xiliang, W. Ruoshui, H. Molin, Eric M. (2010) A Study of the Role Played by Renewable Energies in China's Sustainable Energy Supply. Energy, 35(11), p.4392–4399

[46] Naim H. A., Darwish A. G., Maria G. C., Maurizio C. (1998) Sustainable energy development. Renewable and Sustainable Energy Reviews, 2(3), p.235-286

[47] P.D. Lund. (2009) Effects of energy policies on industry expansion in renewable energy. Renewable Energy, 34(1), p.53–64

[48] Steven C. and Arun M. (2012) Opportunities and challenges for a sustainable energy future. Nature, VOL 488, p. 294-303

[49] Jefferson W.T., et al. (2005) Sustainable Energy: Choosing Among Options. ISBN: 0-262-20153-4. US: MIT Press

[50] Jebaraj S. and Iniyan S. (2006) A review of energy models. Renewable and Sustainable Energy Reviews, 10(4), p.281–311.