Impacts of renewable energy promotion on income and employment in the Republic of Korea[1][2]

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Abstract

Renewable energy promotion is considered together with energy efficiency improvement as an option to mitigate greenhouse gas emissions. Advocates of renewable energy promotion argue that such incentives are justified as impacts of investments in RES on income and employment are positive. However, other studies express concerns on RES promotion. Impacts of such investments on income and employment will largely depend on the productivity of investments in RES. The discussion shows that the productivity of RES is very low due to their higher investment requirements and limited fuel cost saving. Thus, the discussion on impacts of investments in RES on income and employment seems to be not very relevant. More relevant will be the discussion on the cost-effectiveness of CO_2 emissions reduction which is the major climate policy objective. Any subsidy payment scheme, whether in the form of FIT or RPS, should be designed to reduce CO_2 emissions cost-effectively. As the technology specific subsidy payment scheme favors PV and is not cost-effective, one should consider the introduction of a uniform subsidy per kWh of electricity generated or per ton of CO_2 emissions reduced from RES which should be more market conform.

Keywords: Renewable energy promotion, Renewable energy policy

1. Introduction

Renewable energy promotion is considered together with energy efficiency improvement as an option to mitigate greenhouse gas emissions. As most renewable energy sources (RES) have not yet been economical compared to traditional fossil fuels, many governments have promoted RES with tax and subsidy incentives. Advocates of renewable energy promotion argue that such incentives are justified as impacts of investments in RES on income and employment are positive. For instance, an EU financed study concludes that policies supporting RES would give a significant boost to the economy and the number of jobs in the EU. Improving current policies to supply 20% of final energy consumption with RES by 2020 would provide a net effect of about 410,000 additional jobs and 0.24% additional GDP in the EU.

However, other studies express concerns on RES promotion. A Danish study says that “in the long run, creating additional employment in one sector through subsidies will detract labor from other sectors, resulting in no increase in net employment but only in a shift from the non-subsidized sectors to the subsidized sector” (CEPOS, 2009). An EU sponsored Spanish study claims that the programs creating green jobs would have resulted in the

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destruction of nearly 110,500 jobs elsewhere in the economy, or 2.2 jobs destroyed for every "green job" created. (Alvarez et al., 2009) Moreover, a German report claims that the German renewable energy policy, and in particular the adopted feed-in-tariffs would have failed to harness the market incentives needed to ensure a viable and cost-effective introduction of renewable energies into the country's energy portfolio. In the case of photovoltaic, Germany's subsidization regime would have reached a level that by far exceeds average wages, with per-worker subsidies as high as 175,000 € (USD 240,000). (RWI, 2009) Moreover, Hughes argues that the electricity generation from RES cannot be economical due to its high capital-intensity. The capital cost of wind energy, for instance in Great Britain, would be estimated at 9 to 10 times the amount required to meet the same demand by relying upon conventional power plants. He estimates that the cumulative impact of current British RES promotion policies would amount to a loss of 2 to 3% of potential GDP for a period of 20 years and more. (Hughes, 2011)

This discussion shows that impacts of investments in RES on income and employment will largely depend on the productivity of investments in RES, which can be compared with such productivity in conventional energy sources or in the manufacturing industry. RES will become competitive compared to conventional energy sources if its kWh generation cost decreases to the level which is higher only by the cost of reducing CO_2 emissions. Thus, the productivity of investments in RES, in turn, will depend on the cost of investments required to meet the same demand by relying upon conventional energy sources on the one hand and the cost of reducing CO_2 emissions on the other hand. It is a question to answer what is the amount of opportunity costs of renewable energy promotion.

This study tries to assess impacts of renewable energy promotion on income and employment in Korea by using the opportunity cost approach applied by studies mentioned above. The question is whether such promotion can be justified from the economic view point. Moreover, this study discusses whether the technology specific subsidy scheme in the form of feed-in-tariffs (FIT) or renewable portfolio standards (RPS) is the most cost-effective scheme to reduce CO_2 emissions. This paper is organized as follows. Section 2 discusses the renewable energy policy in Korea. Section 3 reviews discussions on the impacts of RES on income and employment. Impacts of RES on income and employment are analyzed in Sections 4 and 5. The paper ends with conclusions and policy recommendations.

2. Renewable energy policy in Korea

The Korean government has embarked to promote RES. However, the results of this promotion have been rather modest. Korea produced RES in the amount of 3.757 million tons of oil equivalent (Mtoe) or 1.52% of the total primary energy supply (TPES) in 2010, as can be seen in Table 1. This share is one of the lowest among OECD countries.

The Korean government introduced the *Alternative Energy Development Promotion Act* in 1987 to promote alternative energy. This act was revised in 1997 and renamed as the *Alternative Energy Development, Use and Promotion Act*. And it was amended in 2004. This act was designed to support among others commercialization of RES, R&D in RES, establishment of standards in RES equipments and parts, and establishment of an institution on RES statistics. This act contains a provision to formulate and implement the so-called *Basic Plan for Development, Use and Deployment of RES Technology* every five years. The *2nd Basic Plan* of 2003 aimed to raise the production share of RES in TPES to 5% by 2011 and 9% by 2015. The Korean government pushed ahead various policies to disseminate wind power, photovoltaic (PV), small hydro, bio-fuel, etc. In addition, Korea introduced the feed-in-tariffs (FIT) scheme to accelerate the deployment of RES in 2002. This scheme has been financed by the so-called *Electric Power Infrastructure Fund* which was established in

2001 and which has been generated by a levy of 3.7% on electricity bills of all consumers in Korea.

Table 1: RES production in Korea, 2001-2010

		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
TPES	Mtoe	190.96	198.59	202.64	208.20	210.10	213.52	222.15	226.95	229.18	246.52
Renewables	Mtoe	1.795	1.853	2.235	2.396	2.484	2.771	3.111	3.342	3.433	3.757
Renewables share	%	0.94%	0.93%	1.10%	1.15%	1.18%	1.30%	1.40%	1.47%	1.50%	1.52%
- Hydro	Mtoe	0.357	0.278	0.422	0.372	0.316	0.298	0.312	0.264	0.242	0.317
- Geothermal	Mtoe					0.003	0.006	0.011	0.016	0.022	0.034
- Photovoltaics	Mtoe	0.001	0.001	0.001	0.001	0.001	0.003	0.006	0.025	0.049	0.092
- Solar (thermal)	Mtoe	0.037	0.035	0.033	0.036	0.035	0.033	0.029	0.028	0.031	0.030
- Wind	Mtoe	0.001	0.001	0.002	0.004	0.011	0.021	0.032	0.037	0.059	0.070
- Biofuel	Mtoe	0.181	0.226	0.263	0.238	0.385	0.432	0.551	0.580	0.691	0.719
- Waste	Mtoe	1.218	1.312	1.514	1.745	1.733	1.978	2.169	2.390	2.332	2.488
- Other sources	Mtoe							0.001	0.002	0.007	0.007

Source: IEA, Energy Balances of OECD countries, 2011 edition.

The *3rd Basic Plan for Development, Use and Deployment of RE technology of 2008* revised the targets of the 2nd Basic Plan for the production share of RES to 4.3% in TPES by 2015 and 11% in TPES by 2030 (Table 2). It contains to introduce the so-called Renewable Portfolio Standards (RPS) scheme starting from 2012 and to phase out the FIT scheme by 2011. The main reason for the shift of the RES promotion scheme was a rapidly growing amount of FIT payments. Under the RPS scheme, 14 state-run and private power utilities with a capacity more than 500 MW are obliged to generate 4% of electricity with RES by 2015 and 10% by 2022. The Korean government hopes with this scheme to increase the generation capacity with RES by 350 MW yearly until 2016 and by 700 MW yearly until 2022.

Table 2: Targets of 3rd Basic Plan for Development, Use & Deployment of RES Technology

Unit: Thousand toe

	2008	2010	2015	2020	2030	Annual growth (%)
Total (RES)	6,360	7,566	11,731	17,520	33,027	7.8
Solar (thermal)	33	40	63	342	1,882	20.2
Solar (photovoltaic)	59	138	313	552	1,364	15.3
Wind power	106	220	1,084	2,035	4,155	18.1
Bio fuels	518	987	2,210	4,211	10,357	14.6
Hydro	946	972	1,071	1,165	1,447	1.9
Geothermal	9	43	280	544	1,261	25.5
Tide (ocean)	0	70	393	907	1,540	49.6
Waste	4,688	5,097	6,316	7,764	11,021	4
TPES (Million toe)	247	253	270	287	300	0.9
Share of RES	2.58%	2.98%	4.33	6.08%	11.00%	

Source: MKE (2008).

It is to note that there are differences in the statistics on production of RES and TPES for the years 2008 and 2010. First, the Korean energy statistics are overestimated mostly due to double-counting of backflows of naphtha from the petrochemical sector to refineries. (Park, 2005) Second, the Korean renewable energy statistics does not follow the established practices of the International Energy Agency (IEA). For instance, it assumes some of exhaust gas recaptured of the fossil fuel origin to raise energy efficiency as RES. The Korean RES production figure with 6.36 Mtoe in 2008 is by about 3 Mtoe higher than that of the IEA statistics 3.343 Mtoe. Therefore, the RES production targets of the Korean government are unrealistic.

Table 3: RES budget of the Korean government, 2003-2011

Unit: Billion won

	2003	2004	2005	2006	2007	2008	2009	2010	2011 (Plan)	2003-2010
R&D	37.0	73.0	94.1	124.5	132.6	208.8	219.4	252.8	267.7	1142.2
Deployment	75.4	98.9	186.2	249.3	263.0	449.0	315.4	292.0	311.8	1929.2
FIT	5.6	5.0	7.5	10.0	26.6	119.5	262.7	331.8	395.0	768.7
Infrastructure									29.0	0.0
Total	118.0	176.9	287.8	383.8	422.2	777.3	797.5	876.6	1003.5	3840.1

Sources: MKE and KEMCO.

The RES budget of the Korean government increased from 118 billion won (USD 99 million) in 2003 to 876.6 billion won (USD 758.1 million) of 2010 (Table 3). The R&D budgetary supports for RES increased by 6.8 times in the period 2003-2010. Five percent of expenditures in R&D for RES are tax deductable. And customs duties are exempted by 50% on imports of components and equipments used for generation facilities for RES. The Korean government also provides subsidies through local governments on the installation of renewable facilities up to 60% of the costs and preferential loans on RES projects.

Table 4: Electricity generation with RES and FIT payments in Korea, 2002-2011

		2002-2005	2006	2007	2008	2009	2010	1st half of 2011	Total
Hydro	**GWh**	566.2	157.3	219.8	205.1	192.3	350.7	147.6	**1,839.1**
	Billion won	11.5	0.7	2.1	2.1	2.2	4.0	1.7	**24.2**
L F G	**GWh**	398.7	119.2	273.8	409.6	374.7	433.6	189.4	**2,199.1**
	Billion won	4.6	0.3	1.7	2.3	2.1	2.5	1.1	**14.6**
Wind	**GWh**	164.3	207.7	333.6	349.5	446.2	847.6	452.6	**2,801.4**
	Billion won	5.1	5.5	7.8	0.5	6.8	0.5	0.0	**26.2**
P V	**GWh**	0.5	5.5	24.1	205.8	420.2	565.1	380.8	**1,602.0**
	Billion won	0.3	3.5	14.6	112.9	240.4	292.7	184.4	**848.7**
Fuel cell	**GWh**	0.0	0.2	2.0	12.2	61.7	200.8	119.5	**396.4**
	Billion won	0.0	0.0	0.4	1.7	11.0	32.0	17.9	**63.1**
Biogas	**GWh**	0.0	0.0	1.6	3.2	5.9	10.7	4.5	**25.8**
	Billion won	0.0	0.0	0.0	0.0	0.1	0.1	0.0	**0.3**
Biomass	**GWh**	0.0	0.0	0.0	0.0	0.9	14.5	8.0	**23.4**
	Billion won	0.0	0.0	0.0	0.0	0.0	0.1	0.0	**0.1**
Waste	**GWh**	0.0	0.0	0.0	0.0	1.2	4.9	2.4	**8.5**
	Billion won	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Total	**GWh**	**1,129.7**	**489.9**	**854.8**	**1,185.4**	**1,503.0**	**2,427.9**	**1,304.8**	**8,895.6**
	Billion won	**21.5**	**10.0**	**26.6**	**119.5**	**262.7**	**331.8**	**205.1**	**977.2**

Source: Korea Energy Management Corporation.

As the FIT subsidy payments are guaranteed for 20 years, the effective governmental supports or subsidies will be much bigger than annual subsidy payments. The guaranteed total FIT payments for the period 2010-2029 could amount to 4.440 trillion won (USD 3.840 billion) if assumed an annual electricity market price increase of 5% and an annual inflation of 3%, as can be seen in Table8. The FIT payments have increased steadily since its introduction in 2002, as can be seen in Table 4. PV operators take most advantages under the present FIT scheme. The share of PV in the FIT payments has been around 90% since 2008, although its share in the electricity generation with RES has been less than 30%. It is interesting to note that the FIT payments for wind are marginal and the system marginal price (SMP) was in the first half of 2001 high than the FIT rate for wind due shortages in the generation capacities in the recent years.

3. Review of discussions on the impacts of RES on income and employment

Renewable energy promotion is considered together with energy efficiency improvement as the option to mitigate greenhouse gas emissions. As most renewable energy sources (RES) have not yet been economical compared to conventional energy sources, many governments have promoted RES with tax and subsidy incentives. Advocates of renewable energy promotion argue that such incentives are justified as their impacts on income and employment are positive. For instance, an EU financed study concludes that policies supporting RES would give a significant boost to the economy and the number of jobs in the EU. Improving current policies to supply 20% of final energy consumption with RES by 2020 would provide a net effect of about 410,000 additional jobs and 0.24% additional GDP in the EU. This study analyzes positive and negative effects of RES on employment and income by considering 1) increased investments, operation and maintenance costs and biomass fuel supply for RES, 2) reduced investments, operation and maintenance costs in the conventional energy sector, 3) fossil fuel imports and use avoided, 4) increasing energy costs and their effects on the economy due to reduced competitiveness (industry) or reduced budgets for consumption (consumers and governments) and 5) trade in RES technology and fuels among EU countries and with the rest of the world. (Ragwitz et al., 2009)

However, other studies express concerns on RES promotion. A Danish study says that "in the long run, creating additional employment in one sector through subsidies will detract labor from other sectors, resulting in no increase in net employment but only in a shift from the non-subsidized sectors to the subsidized sector". And "the Danish manufacturing industry's value-added would be about 1.8 billion DKK ($270 million) per year higher if the energy sector (wind energy) were to reach the average of the broader manufacturing industry's performance." (CEPOS, 2009) An EU sponsored Spanish study claims that the programs creating green jobs would have resulted in the destruction of nearly 110,500 jobs elsewhere in the economy, or 2.2 jobs destroyed for every "green job" created. And it says that "renewables consume enormous taxpayer resources. In Spain, the average annuity payable to renewables is equivalent to 4.35% of all VAT collected, 3.45% of the household income tax, or 5.6% of the corporate income tax for 2007" (Alvarez et al., 2009).

Moreover, a German report claims that the German renewable energy policy, and in particular the adopted feed-in-tariff would have failed to harness the market incentives needed to ensure a viable and cost-effective introduction of renewable energies into the country's energy portfolio. To the contrary the government's support mechanisms would have in many respects subverted these incentives, resulting in massive expenditures that show little long-term promise for stimulating the economy, protecting the environment, or increasing energy security. In the case of photovoltaic, Germany's subsidization regime would have reached a level that by far exceeds average wages, with per-worker subsidies as high as 175,000 € (US $ 240,000). (RWI, 2009) It is very expensive. For instance, PV plants set up in the period 2000-2010 would result in consequential costs (subsidies) in the amount of 81.5 billion € (USD 111.8 billion) in Germany. (FAZ, 2011)

Furthermore, Hughes argues that the electricity generation from RES cannot be economical due to its high capital-intensity. The capital cost of wind energy, for instance, would be estimated at 9 to 10 times the amount required to meet the same demand by relying upon conventional power plants. He estimates that the cumulative impact of current British RES promotion policies would amount to a loss of 2 to 3% of potential GDP for a period of 20 years and more. As far as employment is concerned, he further argues that total income, or value-added, or welfare is what matters, not the number of jobs. He estimates the average cost of reducing CO_2 emissions for the shift from conventional to renewable electricity generation without macroeconomic consequences in Great Britain at more than £250 per ton. (Hughes, 2011)

The discussion has shown that impacts of investments in RES on income and employment will largely depend on the productivity of investments in RES, which can be compared with such productivity in conventional energy sources or in the manufacturing industry. RES will become competitive compared to conventional energy sources if its kWh generation cost decreases to the level which is higher only by the cost of reducing CO_2 emissions. Thus, the productivity of investments in RES, in turn, will depend on the cost of investments required to meet the same demand by relying upon conventional energy sources on the one hand and the cost of reducing CO_2 emissions on the other hand. It is a question to answer what is the amount of opportunity costs of renewable energy promotion. It is about whether investments in RES would result in more or less income and employment than investments in conventional energy sources or in the manufacturing industry. As far as the employment effect of investments in RES is concerned, job creation will also depend on the productivity of such investments. Job creation will be desirable only under increasing overall income.

4. Impacts on income

The renewable energy promotion is often justified as policy measures to create jobs and to generate income by reducing CO_2 emissions. As mentioned before, an EU financed study concludes that policies supporting RES give a significant boost to the economy and the number of jobs in the EU. Improving current policies to supply 20% of final energy consumption with RES by 2020 will provide a net effect of about 410,000 additional jobs and 0.24% additional GDP in the EU by 2020 (Ragwitz et al., 2009).

Were renewable energy promotion required to meet the climate policy objective, then CO_2 emissions should be reduced most cost-effectively. There are various technologies to reduce them. Many governments promote technology (such as photovoltaic (PV) and wind) specifically with feed-in-tariffs (FIT) or renewable portfolio standards (RPS) schemes. Table 5 gives abatement costs of renewable energy sources in Korea for the year 2010.

Table 5: Abatement costs of renewable energy sources in Korea, 2010

	Unit	Bio-fuel	Bio-gas	Photovoltaics	Wind	Sub-total	Waste	Total
Generation	GWh	48	493	1,073	812	2,426	175	2,601
FIT[1)] (A)	won/kWh	189.36	189.36	463.37	107.29			
Wholesale price[2)] (B)	won/kWh	75.82	75.82	75.82	75.82			
Net subsidy (C = A - B)	won/kWh	113.54	113.54	387.55	31.47			
Gross abatement cost[3)]	USD/t CO2	332.9	332.9	814.5	188.6			
Net abatement cost	USD/t CO2	199.6	199.6	681.2	55.3			
CO2 certificate[4)]	USD/t CO2	25.0	25.0	25.0	25.0			
Net abatement cost to CO2 certificate		8.0	8.0	27.2	2.2			

1) Bio-fuel and bio-gas: 68.07 won + SMP + 5 won; PV: 463.37 won/kWh (capacity: between 200 kW and 1 MW).
2) Electricity purchased by the sole distributor KEPCO.
3) The exchange rate for 2010 was 1156.3 won per 1 USD.
4) USD 18.7 (Euro 14.0) for 2009, World Bank, Carbon Finance at the World Bank 2010.

The kWh rates for FIT payments in 2010 were 463.37 won (about 40 US cents) for PV, 189.36 won (16.4 cents) for bio-fuels and 107.29 won (9.3 cents) for wind. PV was with 463.37 won per kWh most expensive technology for the CO_2 emissions reduction. The net abatement costs calculated as the net subsidies per ton of CO_2 were USD 681.2 for PV, USD 199.6 for bio-fuels and USD 55.3 for wind, whereas the net abatement cost is the difference between the FIT rate and the price of electricity purchased by the sole electricity distributor KEPCO (Korea Electricity Power Corporation).These net abatement costs were 27.2 times for PV, 8 times for bio-fuels and 2.2 times for wind the price of a CO_2 certificate assumed at USD 25. At the moment such a certificate costs well below USD 20. It is to question whether a system of technology specific FIT would be desirable. Wind energy reduced 11 times [(387.55/31.47) – 1] more CO_2 emissions than PV with the same cost in Korea for 2010.

Indeed, the technology specific subsidy payment scheme favors PV and is very expensive. Table 4 clarifies this statement. PV generated 380.8 GWh or 29.2% of electricity generation with RES in Korea in the first half of 2011, while it claimed 184.4 billion won (about USD 170.5 million) or 89.9% of the FIT payments. In this connection, a RWI report says that "rather than affording PV this unfair advantage, it would make more sense to extend a uniform subsidy per kWh of electricity from RES. This would allow market forces, rather than political lobbying, to determine which types of RES could best compete with conventional energy sources." (Frondel et al., 2009)

The above calculation does not consider timing of electricity generation with RES. The generation of one kWh or reduction of one ton of CO_2 emissions is considered equal whenever it occurs. As electricity is only generated when the wind blows or the sun shines, RES require additional investments to provide backup capacities. Hughes (2011) argues that "to meet hour-to-hour variations in demand for electricity, for every 100 MW of wind generation capacity it is necessary to have backup capacity, usually provided by gas-fired plants, of 80-100 MW to meet demand during periods when demand is high and the wind is not blowing, as in the UK during December 2010."

Table 6: Load factors of wind and PV in Germany, 2001 - 2010

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Wind	Capacity (MW)	6097	8750	11989	14604	16623	18390	20579	22194	23836	25716	27204
	MW[1)]		6981	9830	12861	15277	17212	19120	21117	22741	24463	26212
	Generation (GWh)	7550	10509	15786	18713	25509	27229	30710	39713	40574	38639	37793
	Load factor		17.2%	18.3%	16.6%	19.1%	18.1%	18.3%	21.5%	20.4%	18.0%	16.5%
PV	Capacity (MW)	76	186	296	435	1105	2056	2899	4170	6120	9914	17320
	MW[1)]		113	223	342	658	1422	2337	3323	4820	7385	12383
	Generation (GWh)	64	76	162	313	556	1282	2220	3075	4420	6583	11683
	Load factor		7.7%	8.3%	10.4%	9.6%	10.3%	10.8%	10.6%	10.5%	10.2%	10.8%

Source: BMU, Erneuerbare Energien in Zahlen: Nationale und internationale Entwicklungen, Berlin, Juli 2011.

Note: 1) For the calculation of load factors only one third of the year's capacity addition is considered.

Moreover, as load factors of RES are lower than conventional energy sources, RES require substantially larger capacities of wind turbines or PV installations. Hughes (2011) calculates that a wind turbine would require at a load factor of 30% a capacity of at least 1400 MW to replace or substitute a gas power plant of 500 MW at a load factor of 85%. If the load factor of a wind turbine would fall to 20%, its required capacity would rise to more than 2100 MW. For instance, the average load factors of wind and PV in Germany were only about 20% and 11%, respectively in the period 2001- 2010, as shown in Table 6. The average load factor of Spanish PV is estimated at 8.7% (0.7 GWh/MW). (Alvarez et al., 2009)

Thus, the investment requirement for renewable electricity by wind turbines or PV is much higher than conventional energy sources due to relatively low load factors and required backup capacities of RES. Hughes (2011) estimates the requirement of an investment of about £9.5 billion in wind generation plus associated infrastructure per £1 billion of investment in gas-fired generation.[5] The fuel cost saving by wind generation would be greatly reduced by higher operation and maintenance costs of wind turbines and higher gas consumption in gas-fired plants used as backup capacity. “Backup electricity tends to be expensive per MWh, because the plants do not run much, and because the plants have low thermal efficiency because of the costs of starting up and running down”. (Hughes, 2011)

The productivity of renewable energy sector investments is very low due to substantially higher investment requirements and limited fuel cost saving. Any investment will increase income more than the initial investment amount as it will generate income through a multiplier and accelerator effect over the time. Investments in RES will contribute positively to increase the national income only if they are more productive than such ones in the manufacturing industry. This should be so as for RES investments funds will be diverted from other energy sectors or non-energy sectors which is known as crowding effect of investments. However, hardly any investment in RES will be more productive than such ones in other sectors at the moment. Even the most efficient renewable technology, wind energy, is not competitive compared to conventional energy sources as explained before. Therefore, it is very difficult to understand the claim of the study financed by the EU that the EU policy of RES promotion will provide 0.24% additional GDP by 2020. Income will increase in the RES sector but the national income will decrease due to lower productivity of investments in RES. This study does not consider additional investment requirements due low load factors of RES like wind turbines and PV as well as backup capacity required for RES. It assumes also a rather high CO_2 price of €34.20 at constant prices of 2005 for the year 2020, which seems to be very high. Moreover, the positive effect of trade in RES technology should not be included as EU exports also technology products in conventional energy sources and in other manufacturing sectors.

In this context, it is interesting to mention a Danish report which states that “the Danish manufacturing industry’s value-added would be about 1.8 billion DKK ($270 million) per year higher if the energy sector (wind energy) were to reach the average of the broader manufacturing industry’s performance. This has been a clear trend for eight consecutive years with high growth and cannot be explained as temporary or by classifying the energy sector as an infant industry. The underperformance is even more striking in light of the subsidies the industry receives.” (CEPOS, 2009)

Advocates of RES will argue that investments in RES are in the short- and mid-term less productive but they will be competitive in the long-term. Therefore, such investments should be supported by government subsidies. They expect sooner or later the so-called grid parity achieved which supposes decreasing costs of generating electricity with RES due to technical progresses on the one hand and increasing costs of generating electricity with conventional energy sources due to rising fossil fuel prices on the other hand. The achievement of grid parity depends on 1) technical progress, 2) fossil fuel prices and 3) real cost comparison.

First, advocates of RES claim that technical progress will reduce substantially costs of generating electricity with RES. They often assume that the technical progress will occur only in renewable energy technologies. However, there is no evidence that future technical progress will favor renewable energy sources over conventional energy sources (Hughes, 2011). Technical progress will occur in conventional energy sources like combined-cycle gas power plants as well. The indicative capital and O&M costs for electricity generation given in Table 7 shows that there will be no substantial differences in the nature of technology used

[5] Hughes is of opinion that this estimate is rather conservative because it does not allow for the reduction in the average load factor for wind plants if new nuclear and/or clean coal power plants receive guarantees that they will operate on base load as suggested in recent government proposals. (Hughes, 2011)

in different power generation plants. Furthermore, it is not certain whether RES technologies are high tech and whether they provide competitiveness in the international market. The PV industry in Germany and the USA has been facing a lot of difficulties because of mass production of PV installations in China. According to Frankfurter Allgemeine Zeitung, the share of the German industry in the German PV market was only less than 15% and the Chinese share was more than 60% in the first half of 2011. (FAZ, 2011)

Second, as far as future fossil fuel prices are concerned, it is difficult to make any projection. Such prices will certainly increase over time. However, such an increase will not enable RES to gain sufficient competitiveness vis-à-vis conventional energy sources.

Table 7: Indicative capital and O&M costs for electricity generation

	Operating life	Overnight capital cost	Fixed O&M cost	Variable O&M excl fuel	Indicative composition of overnight capital costs (%)				
	Years	£ mln per MW	£1000 per MW per year	£1000 per GWh	Construction	Boilers, turbines, etc	Mechanical & electrical	Solar equipment	Other
Nuclear	60	2.68	43	2.3	15-20%	50-55%	5-10%		20-25%
Coal - advanced	35	1.47	28	1.6	15-20%	55-60%	15-20%		5-10%
Coal - combined-cycle	35	0.61	14	1.6	20-25%	50-55%	10-15%		10-15%
Gas - single cycle	30	0.40	9	3.9	20-25%	50-55%	10-15%		10-15%
Wind - onshore	25	1.30	13	0.0	15%	60-65%	15%		5-10%
Wind - offshore	25	2.72	63	0.0	25-30%	50-55%	15-20%		5-10%
Solar - photovoltaic	20	4.00	20	0.0	10-15%		25-30%	45-50%	10-15%
Solar - thermal	20	3.35	50	0.0	5%	15%	10-15%	55%	10-15%
Biomass	35	2.58	49	5.2	15-20%	55-60%	15-20%		5-10%
Reservoir hydro	50	2.58	13	5.5	50-60%	10-20%	10-15%		15-20%
Pumped storage hydro	50	2.58	13	5.5	50-60%	10-20%	10-15%		15-20%

Source: Hughes, G., The myth of green jobs, 2011, Table 1, p. 24.

Third, real or economic costs of generation with RES are important to compare with such costs of conventional energy sources. Capital costs of investments in RES do not reflect real or economic costs, because they do not consider additional investment requirements due to low load factors of RES and do not include costs of backup capacity. Even if an investment of about £5 billion (instead of £9.5 estimated by Hughes) in wind generation plus associated infrastructure is assumed per £1 billion of investment in gas-fired generation, the most efficient renewable technology, wind, cannot be competitive in comparison to conventional energy sources. The introduction of smart grid can reduce costs of backup capacity, but a large part of additional investment requirements will remain.

The discussion has shown that investments in RES will not generate more income than such ones in conventional energy sources or other economic sectors, even if low load factors and required backup capacity of RES are not considered. If these are considered, the grid parity cannot be achieved even in the long-term. The load factors of wind turbines and PV cannot be substantially raised to compete with conventional energy sources such as nuclear, coal and gas whose load factors reach more than 80% in the base load.

Thus, the discussion on impacts of investments in RES on income seems to be not very relevant. More relevant will be the discussion on the cost-effectiveness of CO_2 emissions reduction which is the major climate policy objective. Any subsidy payment scheme in the form of FIT or RPS should be designed to reduce CO_2 emissions cost-effectively. As the technology specific subsidy payment scheme favors PV and is not cost-effective, one should consider a uniform subsidy per kWh of electricity generated or per ton of CO_2 emissions reduced from renewable energy sources which should be more market conform.

5. Impacts on employment

Green growth is a new national vision in Korea. The Korean government expects job creation in RES like in other countries such as Spain, Denmark, Germany and Great Britain. Job creation will be desirable only under increasing overall income. (Frondel et al., 2009; Hughes, 2011) It will depend on the productivity of investments in RES compared to that in the manufacturing industry. How can compare the labor productivities of investments between the renewable energy sector and the rest of the economy? Alvarez et al. (2009) suggests two methods to calculate such productivities in Spain.

The first method compares the cost of creating a green job with a subsidy payment to RES with the per worker capital investment in the manufacturing industry. This comparison can be made because such a payment diverts funds from other energy sectors or other economic sectors. A positive ratio of per worker subsidy to renewables to per worker capita means a negative employment effect of RES, while a negative ratio means a positive employment effect.

Table 8: Estimation of guaranteed FIT payments

Unit: Billion won for FIT

		2003	2004	2005	2006	2007	2008	2009	2010	Total	2003-2009
FIT		5.59	5.04	7.55	9.96	26.61	119.47	262.65	331.80		436.9
Δ FIT	A	5.60	-0.55	2.51	2.41	16.65	92.85	143.19	69.15		
Subsidy durtion		2010-2022	2010-2023	2010-2024	2010-2025	2010-2026	2010-2027	2010-2028	2010-2029		
Nr of years	B	13	14	15	16	17	18	19	20		
Factor for 5% electricity price increase	C	0.8443	0.8267	0.8083	0.7889	0.7686	0.7472	0.7248	0.7013		
ΔFIT adjusted	D=A*C	4.728	-0.456	2.030	1.904	12.797	69.380	103.782	48.493		
Discount factor for 3% inflation	E	1.4258	1.4685	1.5126	1.558	1.6047	1.6528	1.7024	1.7535		
ΔFIT at end year	F=D/E	3.316	-0.311	1.342	1.222	7.975	41.977	60.962	27.655		
Average of first and end year	G=(A+F)/2	4.458	-0.431	1.926	1.818	12.312	67.415	102.075	48.402		
FIT guaranteed at 2010 prices	H=B*G	57.955	-6.039	28.896	29.091	209.311	1213.471	1939.417	968.033	4440.133	

As one can assume that the employment in RES is made possible by the subsidy payments, the per worker subsidy payment can be compared with the average capital per worker in the manufacturing industry. The total subsidy payments consist of two components, subsidy payments made in the period 2003-2009 and those guaranteed for the duration of 20 years. According to Table 8, the Korean government promoted RES with subsidies in the form of FIT payment of 436.9 billion won in the period 2003-2009. And the FIT payments for the subsequent 20 years for the period until 2029 can be assessed by assuming an annual electricity market price increase of 5% and an annual inflation of 3%.

For instance, the difference of FIT payments between 2009 and 2010, 69.1 billion won in Table 8 is the sum of net subsidies which should be paid yearly until 2029. However, these subsidies will decrease with increasing electricity market prices. This paper assumes an annual increase of 5% for the electricity market prices the period 2010-2029. The electricity price market (the purchasing price by KEPCO) increase was 2.46% per year in the period 1990-2010. Thus, the electricity prices will increase from 75.82 won/kWh to 136.16 won/kWh (+60.34 won or +79.58%) in 2022 and to 191.59 won/kWh (+115.77 won or +152.69%) in 2029. These 60.34 won/kWh and 115.77 won/kWh make 15.57% and 29.87% of the net subsidy of 387.55 won/kWh for PV, respectively. Thus, the values of the years 2022 (for 2003) and 2029 (for 2010) have to discount with the values of 0.8443 and 0.7013, respectively which are shown in row C of Table 8. This paper assumes that all subsidy payments will go to the PV sector as it takes the lion’s share (about 88.4%) of the payments.

In row D of Table 8, FIT differences price increase-adjusted (△FIT adjusted) are calculated by multiplying rows A and C.

On top of this adjustment, these △FIT adjusted have to be discounted for inflation to get their present values. This paper assumes an annual inflation of 3% until 2029. Row E of Table 8 gives discount factors. These factors for the years 2022 and 2029 are 1.4258 and 1.7535, respectively. Thus, △FIT adjusted for 2022 and 2029 can have their present values 3.316 billion won and 27.636 billion won, respectively. In the case of 2010, by dividing the sum of the first year (2010) and the last year (2029) of △FIT adjusted by 2, we get the average yearly value of △FIT adjusted. By multiplying these average values with the number of years the sum of FIT payments price-increase adjusted present values. These payments for the period 2010-2029 could amount to 4.4401 trillion won (USD 3.840 billion). Thus, the total FIT subsidy payments will amount to 4.877 trillion (4.4401 + 0.436.9) won (USD 4.218 billion) for the period 2003-2029. The subsidy payment per worker of 364.5 million won (482 million won for the PV sector) can be assessed by dividing the total amount by the number of workers 13,380 (8,906 for the PV sector) in 2010.

Table 9: Evolution of the RES sector in Korea

		2005	2006	2007	2008	2009	2010
Number of companies		57	77	100	133	192	215
Workers in RES		1,375	2,288	3,691	6,122	10,407	13,380
Sales of RES sector	Trillion won	0.284	0.727	1.254	3.353	5.150	8.128
Exports of RES sector	USD billion	1.674	4.822	7.782	19.585	25.901	45.799
Private sector's Investments	Trillion won			0.719	2.702	2.911	3.558
Capital in manufacturing industry	Trillion won	595.6	634.1	715.5	825.0	861.9	
Workers in manufacturing industry	Thousand	4,130	4,057	4,014	3,963	3,836	4,028

Sources: MKE, Press release; Bank of Korea, Statistics Korea; Korea Statistical Information Service.

And the average capital per worker in 2009 was 224.6 million won which can be calculated by dividing the capital stock of 861.9 trillion won by the number of the workers, 3,836,000 in the manufacturing industry (Table 9). This paper uses the 2009 capital stock for the year 2010, because the one for 2010 is not yet available. The 2010 capital stock of the manufacturing industry will be greater than the one for 2009.

The first ratio can be calculated, in turn, as follows:

$$\frac{Subsidy\_to\_renewables\_per\_wor\text{ker}}{Average\_capital\_per\_wor\text{ker}} = \frac{364.5\_million\_won}{224.6\_million\_won} = 1.623$$

As the ratio is greater than one, the employment effect of the Korean RES sector cannot be positive. If FIT subsidy payments are invested in the manufacturing sector, job creation will be higher by 62% than in the RES sector. Alternatively, this can mean that the creation of one job in the RES sector will result in the loss of 1.6 jobs in the manufacturing sector. Alvarez et al. (2009) analyze for the period 1995- 2005 for Spain and come to a similar result for Spain. The Spanish ratio is 2.2.

The second method applied by Alvarez et al. (2009) compares directly the productivities between the RES sector and the manufacturing industry. The annual subsidy payment per worker is considered as the productivity of RES, while the average salary of the worker is assumed the productivity of the manufacturing industry. According Table 3, the Korean government paid 331.3 billion won as FIT subsidies and 292 billion won for the RES deployment. If divided this sum by the number of workers, 13,380 in 2010, we get an annual subsidy payment per worker of 46.6 million won. And the average salary in the manufacturing industry was 28.8 million won in 2010, according to the Bank of Korea.

The second ratio can be derived as follows:

$$\frac{Annual\_subsidy\_to\_renewables\_per\_worker}{Average\_productivity\_per\_worker} = \frac{46.6\_million\_won}{28.8\_million\_won} = 1.625$$

This ratio is almost equally high as the first ratio. In the case of the study by Alvarez et al. (2009), the first and second ratios for Spain are also equally high with 2.2. As the productivity of the RES sector is lower than in the manufacturing sector, investments in RES with subsidy payments will affect negatively on income and employment. As mentioned before, the Danish study says that the energy technology sector over the period 1999-2006 would have underperformed by as much as 13% compared to the industrial average. It further says that the Danish GDP would have been about USD 270 million higher if the wind sector work force were employed elsewhere. (CEPOS, 2009) Thus, the discussion on the impacts of RES on income and employment is superfluous. RES should be promoted to meet the climate policy objective rather than to generate income and create employment. Here again, it is important to reduce CO2 emissions cost-effectively. It is to avoid a technology specific subsidy payment scheme which favors the PV industry excessively disproportionately.

6. Conclusions and recommendations

The discussion has shown that impacts of investments in RES on income and employment will largely depend on the productivity of investments in RES, which can be compared with such productivity in conventional energy sources or in the manufacturing industry. RES will become competitive compared to conventional energy sources if its kWh generation cost decreases to the level which is higher only by the cost of reducing CO_2 emissions. Thus, the productivity of investments in RES, in turn, will depend on the cost of investments required to meet the same demand by relying upon conventional energy sources on the one hand and the cost of reducing CO_2 emissions on the other hand.

The net abatement costs calculated as the net subsidies per ton of CO_2 were 27.2 times for PV, 8 times for bio-fuels and 2.2 times for wind the price of a CO_2 certificate assumed at USD 25. At the moment such a certificate costs well below USD 20. It is to question whether a system of technology specific FIT would be desirable. Wind energy reduced 11 times more CO_2 emissions than PV with the same cost in Korea for 2010.

The productivity of renewable energy sector investments is very low due to substantially higher investment requirements and limited fuel cost saving. First, the investment requirement for renewable electricity e.g., by wind turbines or PV is substantially higher than conventional energy sources due to their relatively low load factors and required backup capacities. Second, the fuel cost saving e.g., by wind generation would be greatly reduced by higher operation and maintenance costs of wind turbines and higher gas consumption in gas-fired plants used as backup capacity. Thus, investments in RES will not generate more income than such ones in conventional energy sources or other economic sectors. As far as the employment effect of investments in RES is concerned, job creation will also depend on the productivity of such investments. Job creation will be desirable only under increasing overall income. The Korean data on the productivity of RES investments shows clearly a rather negative employment effect as is the case in studies such as by CEPOS and Alvarez et al. The Korean RES sector's productivity is lower than that in the manufacturing industry. It requires more government support in terms of FIT payments than the capital investment in the manufacturing sector for job creation. The annual FIT payment per worker is much higher than the average worker's salary in the manufacturing industry.

Thus, the discussion on impacts of investments in RES on income seems to be not very relevant. More relevant will be the discussion on the cost-effectiveness of CO_2 emissions reduction which is the major climate policy objective. Any subsidy payment scheme, whether in the form of FIT or RPS, should be designed to reduce CO_2 emissions cost-effectively. As the technology specific subsidy payment scheme favors PV and is not cost-effective, one should consider a uniform subsidy per kWh of electricity generated or per ton of CO_2 emissions reduced from renewable energy sources which should be more market conform.

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