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Inclusive and Sustainable Industrial Development Working Paper Series
WP 4 | 2016

PROMOTING RENEWABLE ENERGY AND ENERGY EFFICIENCY IN AFRICA: A FRAMEWORK TO EVALUATE EMPLOYMENT GENERATION AND COST EFFECTIVENESS

DEPARTMENT OF POLICY, RESEARCH AND STATISTICS

WORKING PAPER 04/2016

Promoting renewable energy and energy efficiency in Africa: A framework to evaluate employment generation and cost effectiveness

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Vienna, 2016

Acknowledgements

This research expands on background work carried out for the Industrial Development Reports 2013 and 2016 (UNIDO, 2013; UNIDO, 2016). The authors fully acknowledge the input received from various colleagues within the scope of that process, in particular from Camelia Soare of UNIDO. DMK would like to thank the Karsten Family Foundation and the Zaffaroni Family for their support of the Renewable and Appropriate Energy Laboratory.

Table of Contents

List of Figures

List of Tables

Abstract

The ongoing debate over the cost-effectiveness of renewable energy (RE) and energy efficiency (EE) deployment often hinges on the current cost of incumbent fossil-fuel technologies versus the long-term benefit of clean energy alternatives. This debate is often focused on mature or 'industrialized' economies and externalities such as job creation. In many ways, however, the situation in developing economies is at least as or even more interesting due to the generally faster current rate of economic growth and of infrastructure deployment. On the one hand, RE and EE could help decarbonize economies in developing countries, but on the other hand, higher upfront costs of RE and EE could hamper short-term growth. The methodology developed in this paper confirms the existence of this trade-off for some scenarios, yet at the same time provides considerable evidence about the positive impact of EE and RE from a job creation and employment perspective. By extending and adopting a methodology for Africa designed to calculate employment from electricity generation in the U.S., this study finds that energy savings and the conversion of the electricity supply mix to renewable energy generates employment compared to a reference scenario. It also concludes that the costs per additional job created tend to decrease with increasing levels of both EE adoption and RE shares.

Keywords: *Renewable energy; employment; energy efficiency; Africa*

1. Introduction

A technology- and policy-driven shift towards renewable energy has been advocated on environmental grounds and to a lesser extent, to improve energy security (Kammen, 2015). Mitigating the adverse effects of climate change looming or already present represents an urgent imperative. At the same time, the need to transform our energy system—essentially reproducing the Industrial Revolution within just three decades—opens up vast opportunities for the renewable energy industry (Kammen, 2006; Turkenburg et al., 2012). The developing world has a larger share and much faster growth rate of global energy-related greenhouse gas emissions (GHG) than OECD countries (EIA, 2013). As a result, a huge potential for low cost de-carbonization options exists in the developing world as emphasized in Bowen and Frankhauser (2012). In fact, the implementation of technologies, policies and behavioural strategies in the developing world to reduce the adverse impacts of climate change can—and must—take place, and can be realized at a relatively low cost through the promotion of energy efficiency (EE) and renewable energy (RE).

Increasing the share of RE is also commonly justified as a means to reduce reliance on energy imports (Cherp et al., 2012), thereby reducing the vulnerability of developing countries to energy price shocks (Massa et al., 2012). The developing world is also projected to bear the brunt of shorter term climate change impacts (IPCC, 2014).

The impact of increased deployment of RE and EE has received less attention, particularly in Africa. One of the objectives of this paper is to shed light on this issue and conduct an aggregated analysis to explore the link between RE, EE and employment.

RE continues to grow, both in absolute and relative terms, globally as well as in Africa. So-called modern renewables (i.e. excluding traditional biomass) accounted for approximately 10 per cent of the global energy mix in 2012 (REN21, 2014).

Energy companies are expanding their investment portfolios and becoming more active in Africa. New investments in clean energy in Africa and the Middle East increased from US$ 0.3 billion to US $11.8 billion between 2004 and 2012 (BNEF, 2013). Indeed, business prospects are more appealing in improved environments in countries with dedicated institutional and policy frameworks. Also, with the price of renewables decreasing steadily and the cost of carbon becoming more internalized through various instruments and strategies (including the phasing out of fossil fuel subsidies), such options are becoming increasingly attractive from an investment perspective compared to conventional energy sources.

RE (excluding large hydropower) represented nearly half of the new generation capacity added globally in 2011, up from a minuscule share just a few years earlier. Global investments in renewable power and fuels rose by 17 percent to US$ 257 billion in 2011 – for comparison purposes, investment in fossil fuel generating capacity was US$ 302 billion, with about one-third of that in developing countries (REN21, 2012; UNEP and BNEF, 2012). At the global level, there are now 144 countries with renewable energy policies and the share of low income countries with renewable energy policies grew from 0 per cent to 60 per cent from 2004 to 2014 (REN21, 2014).

The grey literature abounds in claims of the positive impact of promoting RE on employment, often with little substantiation. The literature on the impact of employment on EE is even scanter. The Industrial Development Report (2011) states that energy efficiency may reduce production costs and increase demand owing to the price elasticity of demand, but the "evidence on the impact of energy efficiency on employment generation is still limited" (p. 81).

A few attempts have been made to look into the issue in a more systematic fashion (see Wei, Patadia and Kammen, 2010 for a review of studies). However, pinning down job numbers is challenging (see, e.g. Bowen, 2012), not least for methodological and definitional reasons. Kammen et al. (2004), for instance, compare the pros and cons of various models. Employment estimates rarely capture net effects, self-employment or the informal economy, especially in developing countries where reliable and comprehensive data are scarce.

Rutovitz and Atherton (2009) estimate that there were 9 million jobs in energy globally, with about 20 percent of jobs in 2010 in either the RE industry or in energy savings realized in the generation of electricity. Renner et al. (2008) "conservatively" put jobs in RE and in supplier industries at 2.3 million worldwide. According to Holdren (2007), India alone may be able to generate some 900,000 jobs by 2020 from biomass gasification. Of these, 300,000 jobs are projected to be from gasifier stove manufacturing (including masons and metal fabricators), 600,000 from biomass production, supply chain operations and after-sales services, and 10,000 from workers developing advanced biomass cooking technologies.

As regards to EE, the IEA (2014) estimates values ranging from 7 to 22 job-years per EUR 1 million invested. Compared with the same investment in the fossil fuel industry, EE services reportedly lead to the generation of three times the number of jobs per million dollars invested (ACE, 2000; Pollin et al., 2009).

Wei et al. (2010) developed and applied a model to estimate net job creation in the energy industry, focusing on the power industry in the United States. They found that dedicated policy

measures can spur significant positive impacts in terms of employment. Drawing on this study, we complement the existing literature by adapting and applying the model to developing countries. We also expand the methodology of Wei et al. (2010) to estimate the potential job 'leakage' to other regions. Additionally, we factor in reductions in job multipliers due to technology and their related impact on the jobs dividend. Finally, we also conduct a cost-benefit analysis for the various energy scenarios considered.

2. Methodology

We apply scenario analysis to evaluate the employment potential of an uptake in RE and EE in Africa. We first develop a reference scenario (or baseline scenario) with which to compare alternative future scenarios. We then test the results for robustness using sensitivity analysis. As mentioned in the previous section, Wei et al. (2010) report that a shift of the US economy from fossil fuels to RE and EE would lead to net jobs creation in the energy industry. In this section, we describe how we adapt and apply their methodology and assumptions to estimate the potential direct and indirect job impact of very high increases in RE in Africa.

We define direct job impacts as jobs created (or lost) in the design, manufacturing, delivery construction/installation, project management and operation and maintenance of the different components of the technology under consideration. Indirect employment, on the other hand, refers to upstream and downstream suppliers. Effects on induced jobs (i.e. employment variation through expenditure-induced effects in the general economy from changes in spending patterns by direct and indirect employees) go beyond the scope of this study[1].

Our analytical spreadsheet-based model utilizes the normalization approach of taking average employment per unit of end use energy produced over plant lifetime. These coefficients derive from a meta-study conducted by Wei et al. (2010). The model also computes job losses in the coal and natural gas industries, with the objective of calculating net employment impacts in the energy industry.

[1] Like Wei et al. (2010), we only consider induced jobs for EE (presented in Table 1 as the indirect multiplier), but do not include induced jobs for RE. We consider both direct and indirect jobs for RE.

Table 1 Direct and indirect job coefficients (Jobs/GWh/year)

	Energy efficiency	Biomass	Conventional hydropower	Hydro (small)	Municipal solid waste	Geothermal
Direct	0.04	0.21	0.15	0.27	0.15	0.25
Indirect	9.0	0.9	0.9	0.9	0.9	0.9

	Nuclear	Solar PV	Solar Concentration Power (SCP)	Wind	Coal	Natural Gas	Oil
Direct	0.14	0.87	0.23	0.17	0.11	0.11	0.69
Indirect	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Source: Wei et al. (2010)

We take direct and indirect jobs coefficients for every source of energy from Wei et al. (2010)[2]. Normalized employment multipliers for Africa are used to calculate job creation and destruction in the electricity industry based on Atherton and Rutovitz (2009). The underlying idea is that the direct employment impact of electricity generation is higher in Africa than in OECD countries, as the production process would presumably be less efficient.

Conversely, we assume the same coefficients for indirect employment effects. The literature on the calculation of indirect job creation is characterized by high uncertainty. The International Finance Corporation (IFC, 2013) reports that the indirect jobs/direct jobs ratio lies in the range of 7 - 25. In our study, we use a conservative approach, and correct the direct jobs multipliers of Table 1 on the basis of coefficients in Table 2, but we do not adjust indirect jobs multipliers upwards. We implicitly assume that there are fewer opportunities in Africa to activate forward and backward linkages for multiplier effects. We also assume that the direct jobs/indirect jobs ratio across sources of energy lies in the range of 0.99 - 9.0 as in Wei et al. (2010).

[2] In Wei et al. (2010), a distinction is made between small and conventional hydropower direct and indirect jobs. As we only have data on hydropower (without any distinction between small and conventional), we take an average of the two.

Table 2 Conversion factors of multipliers for direct employment coefficients of electricity generation (Rutovitz and Atherton (2009))

	2010		2020		2030	
	Construction, manufacturing, O&M	Biomass fuel supply	Construction, manufacturing, O&M	Biomass fuel supply	Construction, manufacturing, O&M	Biomass fuel supply
OECD	1.0	1.0	1.0	1.0	1.0	1.0
Africa	6.3	13.7	6.2	13.7	6.3	13.7

To estimate net job impact in Africa, we consider the leakage rate of manufacturing jobs by using estimates of the share of local manufacturing from Rutovitz and Atherton (2009). They estimate the share of manufacturing in Africa to represent 30 per cent and 50 per cent in 2010 and 2030, respectively. As in Rutovitz and Atherton (2009), we also assume that jobs multipliers decrease over time due to technological improvements offsetting job creation (by an annual decrement of 0.9 per cent from 2010 to 2020 and of -0.3 per cent annually from 2020 to 2030).

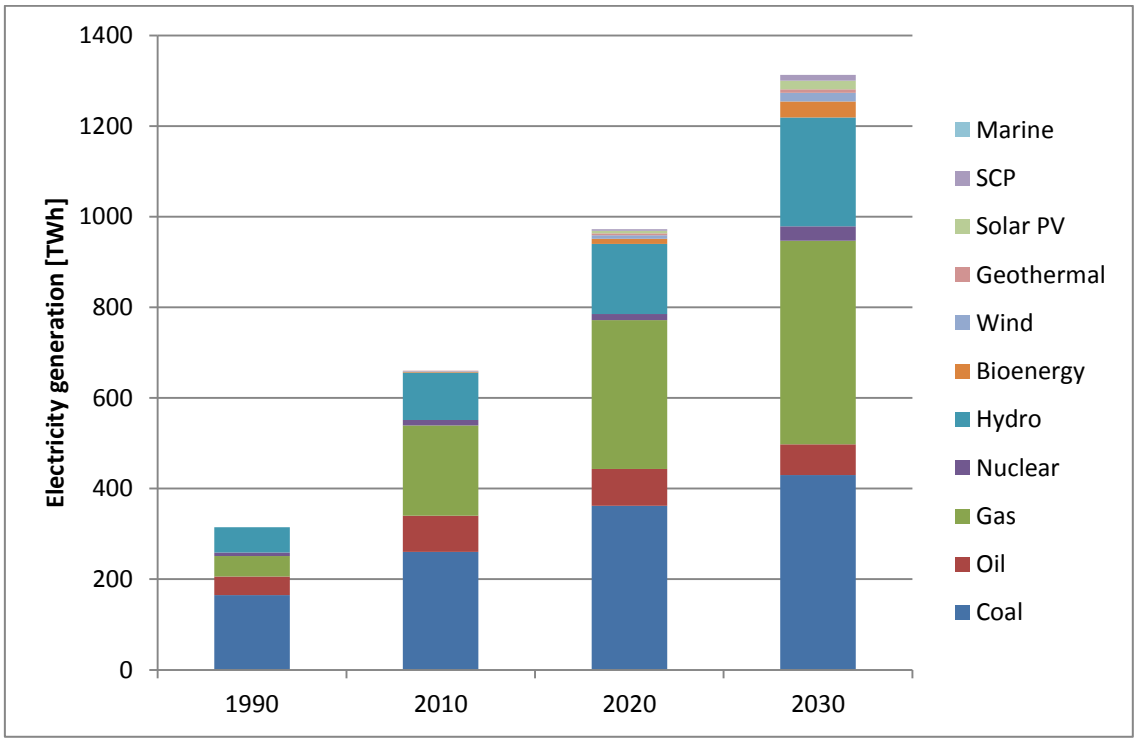
We then take the generation prices[3] for each energy source from Bosetti et al. (2006) to estimate the price of generation for 2020 and 2030[4]. Intermediate prices are estimated using interpolation. Generation costs in Bosetti et al. (2006) are applied to the combined Middle East and North Africa region. To express a cost for Africa, we take the average of the two values. Bosetti et al. (2006) do not estimate the generation costs for geothermal and biomass. On the basis of a study by IRENA (2012), which calculates the weighted average costs for different sources of energy, we assume similar costs for geothermal, biomass and hydropower in Africa. Bosetti et al. assume a cost for concentrated solar power, wind and solar photovoltaics. For the purpose of crosschecking, we compare interpolated prices from Bosetti et al. (2006) for 2012 with minimum and maximum weighted prices of geothermal/biomass/hydropower (from 3 to 10 cents in constant USD in 2011) and wind/solar (from 10 cents to 25 cents in constant USD in 2011) by elaborating IRENA estimates for 2012. Our estimated prices fall within that range (7 cents and 11.5 cents in constant USD in 2011, respectively). Recent estimates of solar costs (Bosetti et al., 2015) indicate a range of 2 cents to 45 cents per kwh in constant USD by 2030, whereas we use 9.33 cents in constant USD in 2011.

[3] In Bosetti et al. (2006), the cost of electricity generation is equal to the sum of the capital invested in power capacity and the expenditure for fuels, operation and maintenance.
[4] See Annex II for WITCH model forecasts of energy prices.

In scenarios in which we introduce reductions in energy demand, we assume that each unit of saved energy costs 50 per cent of the average price of electricity (a share weighted average price of all sources of energy). This is in line with studies arguing relatively cheap opportunities or "low hanging fruit" in developing countries (e.g. up to 25 per cent of energy demand reduction according to McKinsey (2012)) and in line with Molina (2014:39), who claims that "electricity efficiency programs are one half to one third the cost of the alternative of building new power plants." In our analysis, we select the more conservative 50 per cent estimate for the reference scenario.

Initial renewable energy shares are taken from IEA balances for Africa in 2009 and are assumed to increase by 16 per cent in 2010 to 25 per cent in 2030.[5] Demand for electricity in Africa is estimated to reach 1311 TWh by 2030. We apply the revised conversion factors to the electricity generation of our reference scenario. As in Wei et al. (2010), jobs in EE only account for additional jobs from EE compared with the reference scenario. In the reference scenario, we assume energy consumption and shares of RE to be consistent with the IEA's Current Policies scenario (Figure 1).

Figure 1 Current_Policies scenario in Africa



[5] See Annex I for the IEA energy balance for Africa in 2009.

Alternative scenarios are described in Table 3 and are consistent with the IEA's World Energy Outlook "NEW_POLICIES" and "450_PPM" storylines. The former assumes the introduction of new measures on RE and EE (i.e. above and beyond those considered in the Current Policies scenario), assuming that the broad policy commitments that have already been announced are actually implemented. The latter depicts a pathway considered to be consistent with the goal of limiting the global increase in average temperature to 2 °C. The NEW_POLICIES scenario assumes a lower energy demand (1224 TWh) than the CURRENT_POLICIES scenario as well as a lower share of fossil fuel energy (from 75 per cent in the CURRENT_POLICIES scenario to 70 per cent in the NEW_POLICIES scenario). 450_PPM is the most ambitious and environment-friendly scenario, as it assumes 1106 TWh in electricity demand and a 58 per cent fossil fuel share in 2030.

Table 3 Key parameters in 2030 for the scenarios considered

Scenario	Share of renewables in 2030 (biomass, geothermal, municipal solid waste, solar PV, solar thermal, small hydro, wind)	Electricity demand in 2030 (TWh)
CURRENT_POLICIES	25%	1311
NEW_POLICIES	30%	1215
450_PPM	42%	1106

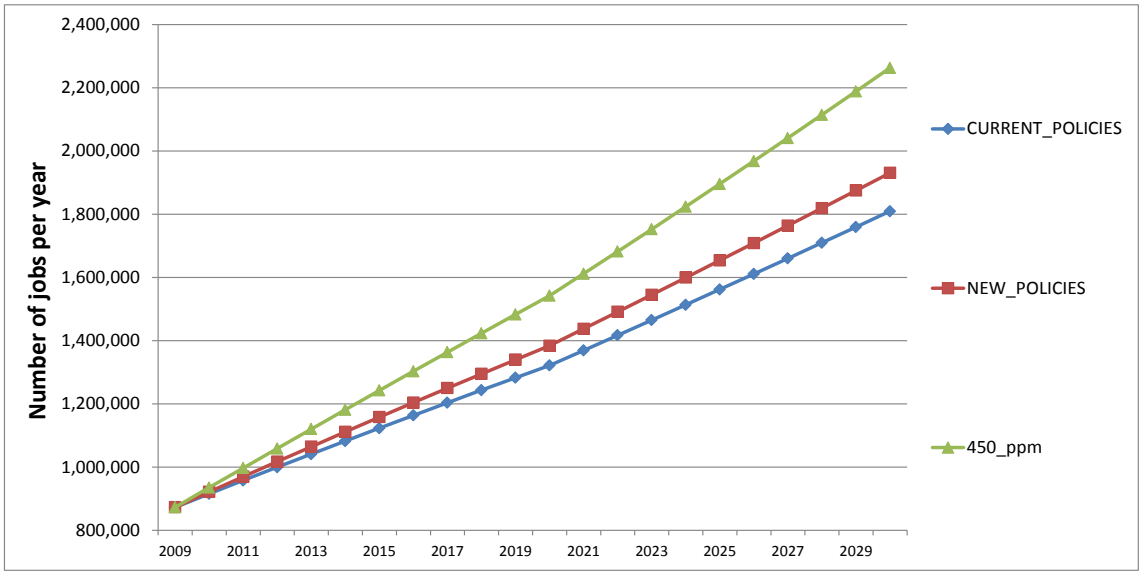
3. Results

We provide output results for the following variables for all scenarios:

- Jobs/year
- Total generation costs (generation cost per kWh for different sources of energy) and ratio of the average cost of RE over the average cost of non-renewable energy
- Generation cost per job per year.

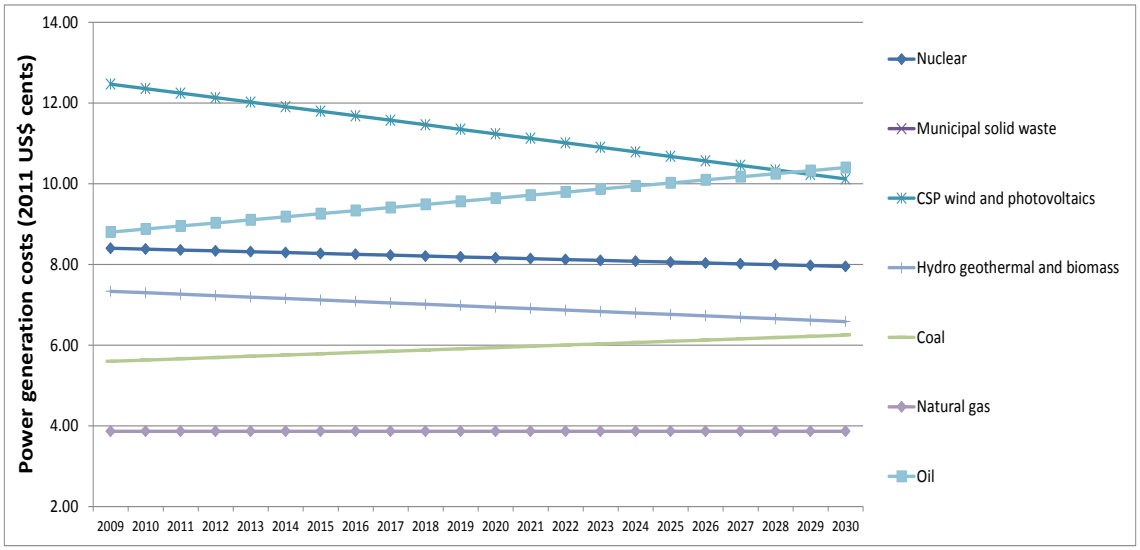
It is interesting to note that the scenario with the highest level of jobs per year in 2030 is 450_PPM, which assumes the highest share of both RE and EE (Figure 2). Note that the 450_PPM scenario results in a loss of jobs deriving from the reduction of electricity generation, but this effect is more than counterbalanced by the jobs created through the expansion of EE and RE.

Figure 2 **Jobs in different scenarios (jobs/year, vertical axis, year horizontal axis)**



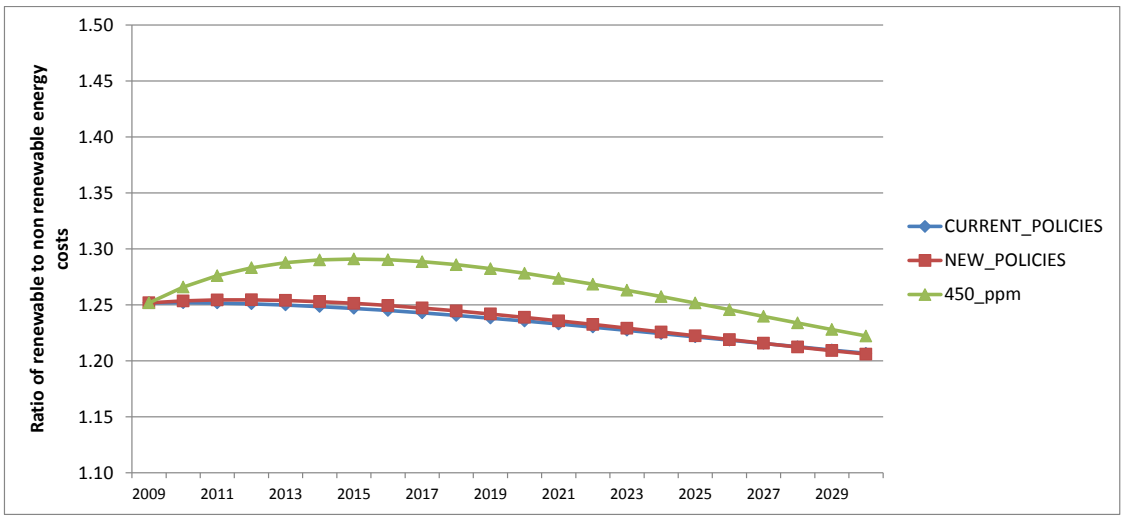
Over the period 2009 – 2030, the reference scenario 'CURRENT_POLICIES scenario'. together with the NEW_POLICES and 450_PPM scenarios, assume an average cost for RE that is higher than that of non-renewable energy (nuclear + fossil fuels). In the reference case, the costs for both RE and fossil fuels decrease, but the reduction in RE costs slightly exceeds the reduction in fossil fuel costs (in 2009, the ratio is assumed to be 1.25 and in 2030, it is assumed to be 1.20) (Figures 3 and 4).

Figure 3 **Power generation costs in Africa for each energy source in the reference scenario (2011 cents of US$/kwh)**



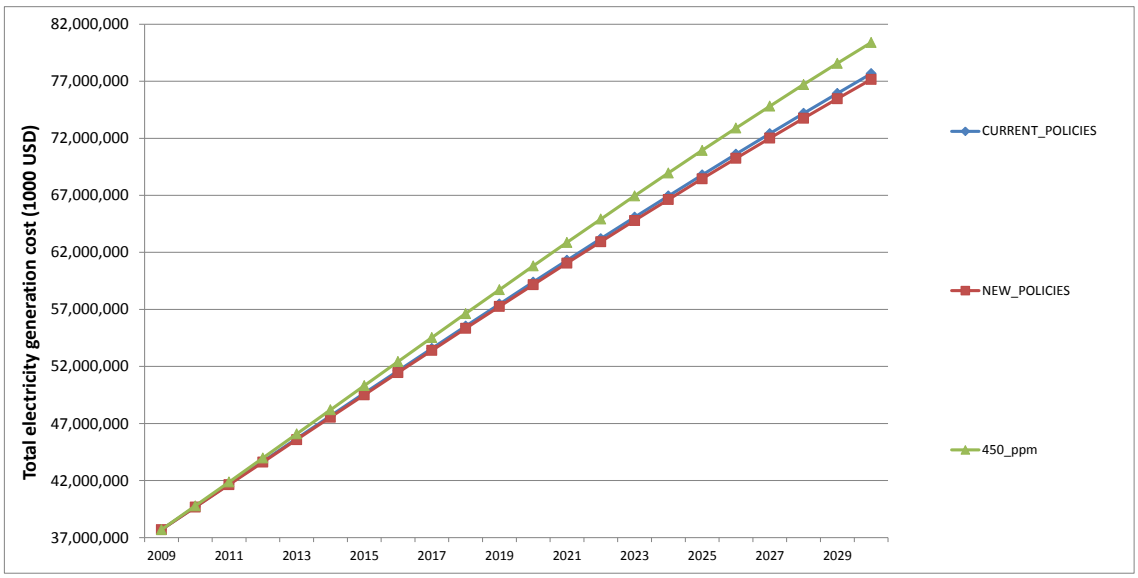
Data for 2002 and 2030 are taken and adapted from the WITCH model (Bosetti et al., 2006), the data for the other years are interpolated.

Figure 4 **Ratio of average cost of renewables over average costs of non-renewable energy generation (oil, gas and coal + nuclear) in different scenarios**



As shown in Figure 5, a high number of employees may generate a trade-off in terms of electricity generation costs. The 450_PPM scenario, which entails the highest renewables cost per kwh (Figure 3 and Figure 4) as well as the largest share of RE, also displays the highest electricity generation costs for Africa. Interestingly, the NEW_POLICIES scenario is cheaper than the reference scenario in 2030. Thus, a higher share of renewables does not always imply an increase in electricity generation costs. The savings from EE outweigh the higher energy costs associated with the increase in the share of RE. In the 450_PPM scenario, energy savings cannot compensate for the increase in electricity generation costs associated with a higher share of RE.

Figure 5 **Electricity generation costs (1,000 2011 USD)**



The 450_PPM scenario, which indicates the highest level of RE share and the lowest level of energy demand, also entails the lowest generation cost per worker (Figure 6). In other words, the scenario with the highest level of additional jobs also displays the lowest electricity generation cost per job created (Figure 7). This result, as already demonstrated in Wei, Patadia and Kammen (2010), is, in effect, related to building a new, clean energy economy. In the 450_PPM scenario, EE and RE generate additional jobs. The increase in electricity generation costs in the scenario grows more slowly than the increase of jobs. Figures 6 and 7 are pivotal and illustrate that the economic argument against the greening of the energy mix is weakened by the evidence which reveals the savings in terms of costs per unit of generated employment.

Figure 6 **Generation cost per worker (1,000 2011 USD per jobs/ year)**

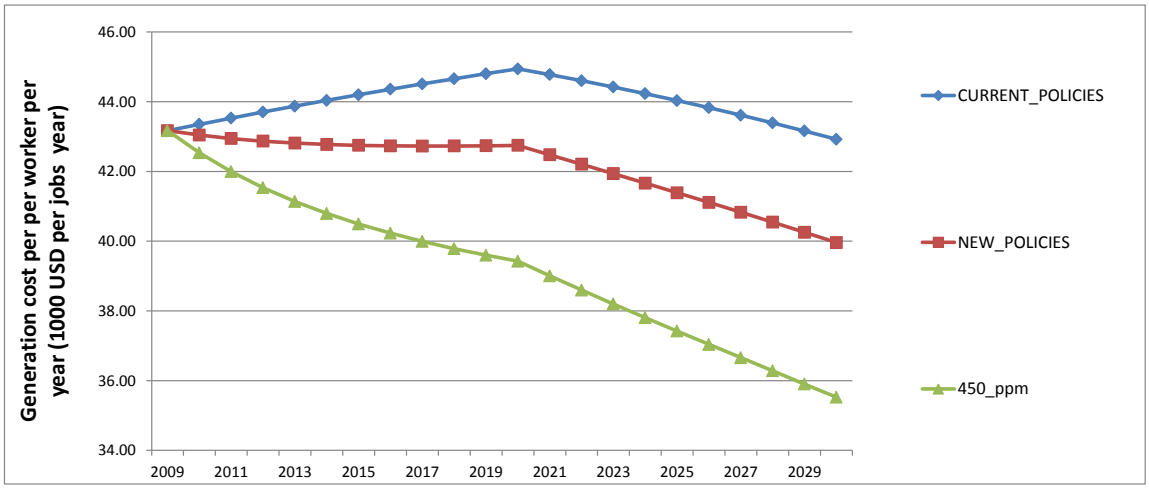
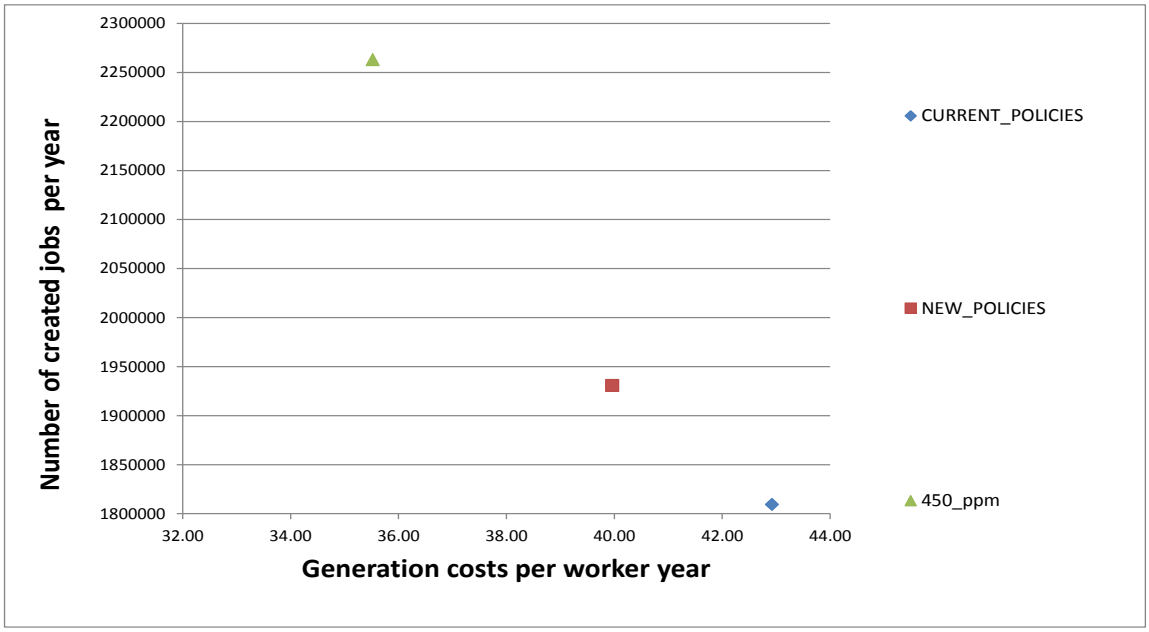


Figure 7 **Zoom on 2030. Generation cost per created job per year (vertical axis) vs number of created jobs per year**



4. Sensitivity analysis

To test the robustness of our results to changes of the relevant parameters, our key assumptions are modified in all scenarios. The previous simulations indicate that EE and RE: 1) create jobs; 2) lead to higher electricity generation costs; 3) produce a lower electricity generation cost per job created. We manipulate: 1) the rate of job losses deriving from a technology parameter expressing the annual rate of reduction of the jobs multiplier; 2) the leakage rate of manufacturing jobs; 3) the price of renewables; 4) the cost of EE.

We increase the technology parameter expressing the annual rate of reduction of the jobs multiplier and the leakage parameter (+ 10%, + 30%, + 50%, + 70%)[6] to analyse the extent to which the 450_PPM and the NEW_POLICIES scenarios continue to generate additional jobs and a cheaper cost per generated job when compared with the CURRENT POLICY scenario. Moreover, we increase the price of both RE and EE (+ 10%, + 30%, + 50, + 70%) to analyse the extent to which the 450_PPM and the NEW_POLICIES scenarios entail lower electricity generation costs (total costs and costs per generated job) compared to the CURRENT_POLICY scenario. We show results for the years 2020 and 2030.

We first discuss the results on the technology parameter (Figure 8) and the leakage parameter (Figure 9). The two parameters show similar impacts. In the CURRENT_POLICY scenario, not surprisingly, technology and an increase of leakage of manufacturing jobs reduce the number of jobs. Electricity generation costs are not affected whereby the generation cost per worker does increase. In the NEW_POLICY scenario, the number of jobs still remains higher and the generation cost per worker is lower than in the CURRENT POLICY scenario with an increase of up to 30 per cent of the technology and leakage parameters. With an increase of the parameters by 50 per cent, the CURRENT_POLICY scenario fares better than the NEW_POLICY scenario. Interestingly, in the 450_PPM scenario, despite major increases in the technology and leakage parameters, the number of jobs remains higher and generation costs per worker remain lower than in the CURRENT POLICY scenario. The results for 2020 and 2030 are similar to those for 2030, which indicate a slightly stronger order of magnitude.

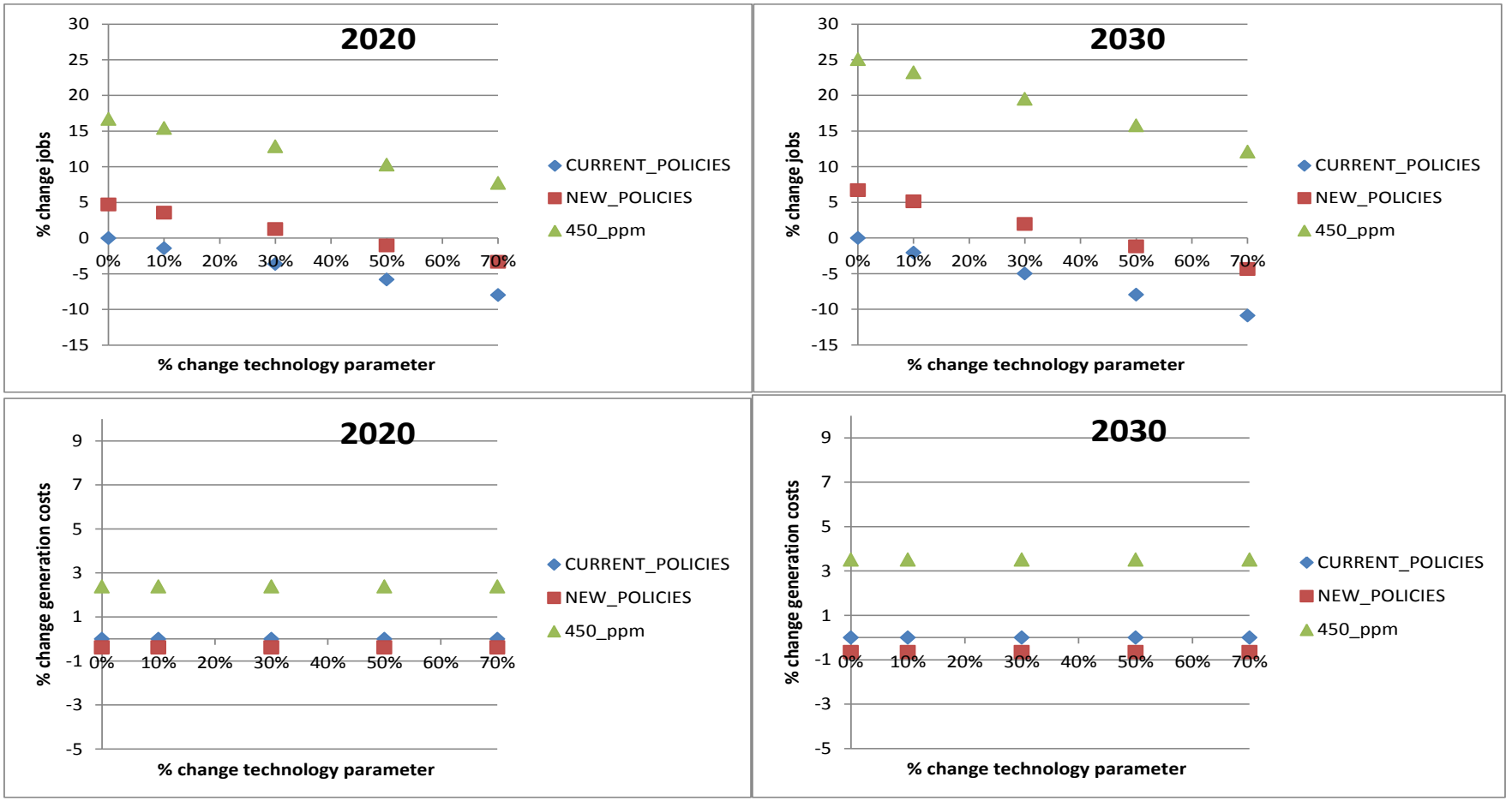
[6] The technology effect is incorporated by increasing the annual decrement of the jobs parameter estimated by Rutovitz and Atherton (for example, for a 10 per cent sensitivity analysis of the technology parameter, we increase the decrements estimated by Rutovitz and Atherton by 10 per cent, from 0.9 to 0.99 up to 2020, and from 0.3 to 0.33 from 2021 to 2030). The leakage effect is captured by varying the leakage rate estimated by Rutovitz and Atherton in 2030 (for example, for a 10 per cent sensitivity analysis of the leakage parameter, we increase the leakage rate estimated by Rutovitz and Atherton by 10 per cent from 0.5 to 0.55 in 2030). By analysing variations of the leakage effect, the value in 2010 remains unchanged as estimated by Rutovitz and Atherton, but the values of the leakage parameter between 2011 and 2030 are interpolated on the basis of the revised value for 2030.

Changes in costs of RE and EE (Figures 10 and 11) have no impact on jobs creation[7]. However, we observe interesting relevant variations in terms of generation costs and generation cost per worker. An increase in the cost of renewables results in the worst case scenario (+ 70 per cent) with a 10 per cent increase in electricity generation costs in 2020 and a 20 per cent increase in 2030 in the CURRENT_POLICY scenario. The CURRENT_POLICY scenario is not discussed in the EE sensitivity analysis, because EE is not considered in that scenario.

In the NEW_POLICY scenario, the reduction in electricity generation costs compared to the CURRENT_POLICY scenario disappears with a 10 per cent increase in RE costs. The generation cost per worker is still lower in 2020 despite an increase in RE costs by up to 30 per cent, and by up to 10 per cent in 2030. In the 450_PPM scenario, the generation cost per worker is lower than in the CURRENT_POLICY scenario for each variation of the cost parameter in 2020, and only up to a 50 per cent increase of the cost parameter in 2050. EE costs do not have a significant impact on the generation cost per worker. As shown in Figure 11, the NEW_POLICY and 450_PPM scenarios have lower generation costs per worker both in 2020 and 2030. This is hardly surprising if we consider that in the scenario with the highest level of EE (450_PPM), energy savings only represent 15 per cent of total electricity generation in the CURRENT POLICY scenario.

[7] A general equilibrium approach would be the most appropriate to capture job variations from RE and/or EE cost parameters.

Figure 8 **Changes based on a modification of the technological parameter relative to the baseline CURRENT_POLICY scenario in terms of jobs, generation costs and generation costs per worker/ year ratio**



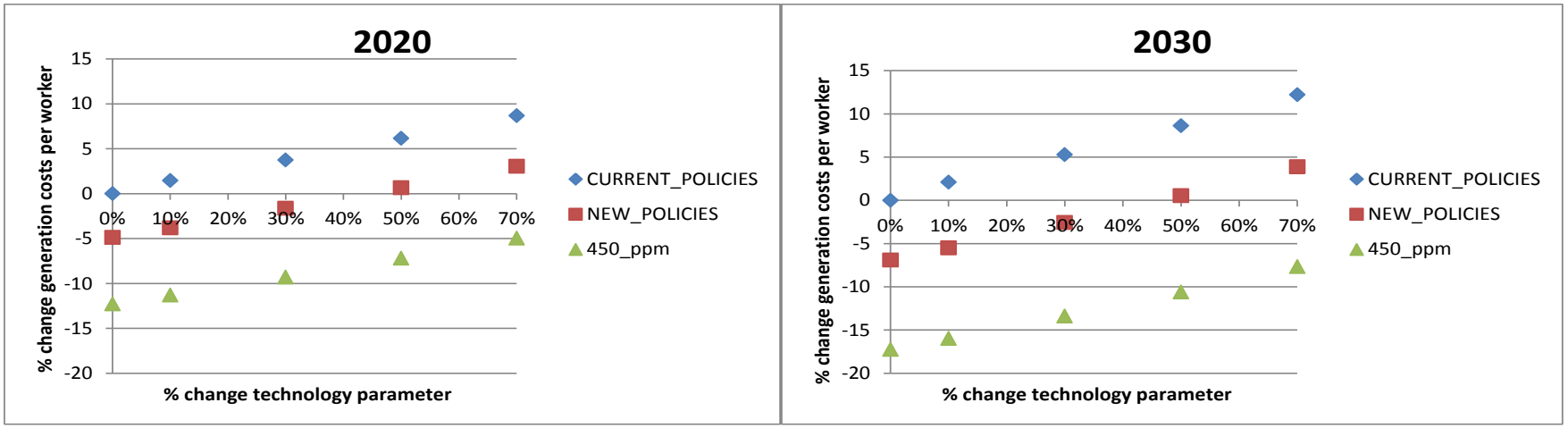
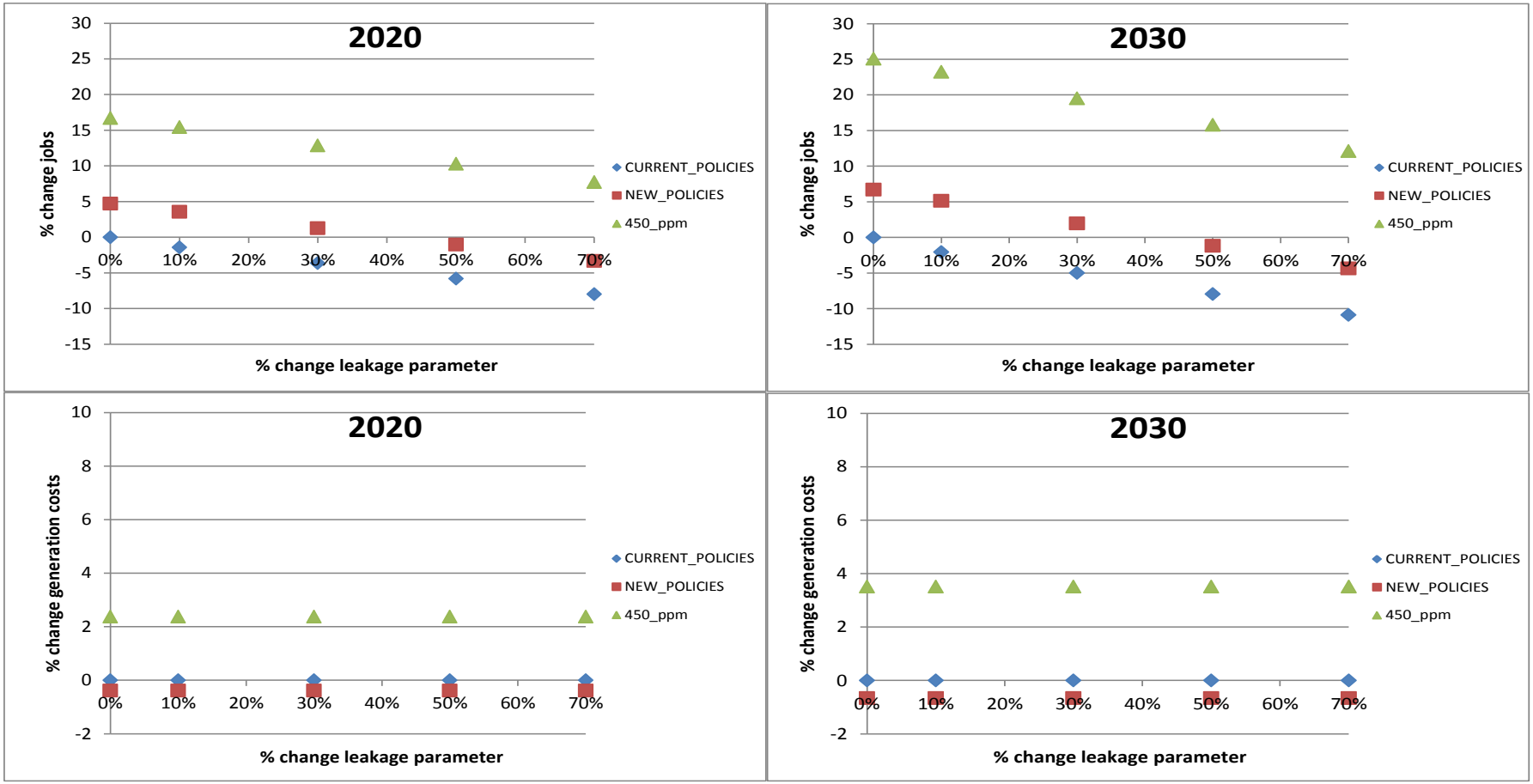
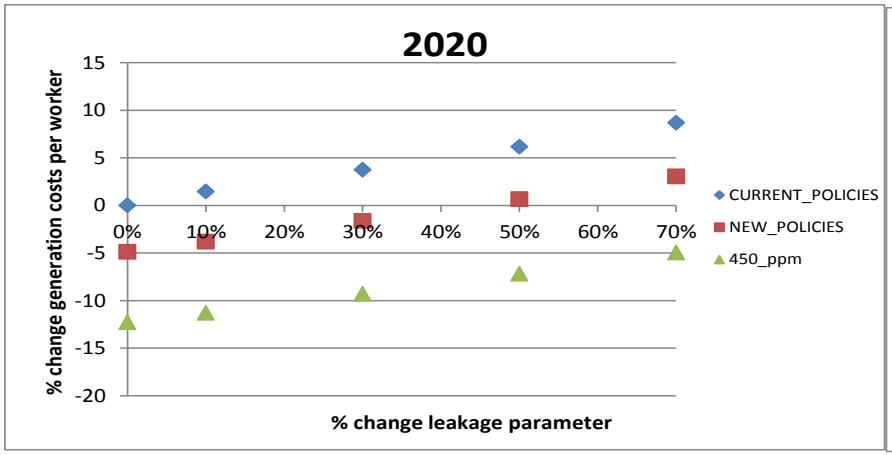

2020
% change generation costs per worker
15
10
5
0
-5
-10
-15
-20
0%
10%
20%
30%
40%
50%
60%
70%
% change technology parameter
CURRENT_POLICIES
NEW_POLICIES
450_ppm
2030
% change generation costs per worker
% change technology parameter
CURRENT_POLICIES
NEW_POLICIES
450_ppm

Figure 9 **Changes deriving from a modification of the leakage parameter relative to the baseline CURRENT_POLICY scenario in terms of jobs, generation costs and generation costs per worker/ year ratio**




2020
% change generation costs per worker
15
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-5
-10
-15
-20
0%
10%
20%
30%
40%
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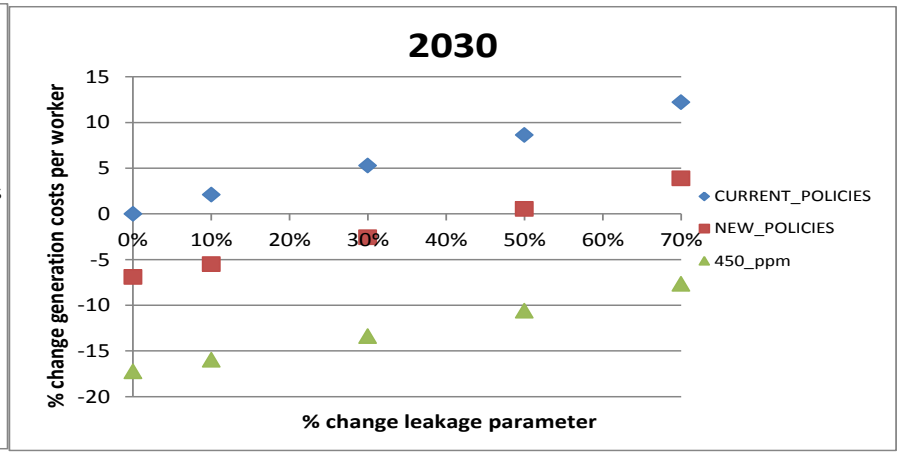
60%
70%
% change leakage parameter
CURRENT_POLICIES
NEW_POLICIES
450_ppm


2030
% change generation costs per worker
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-10
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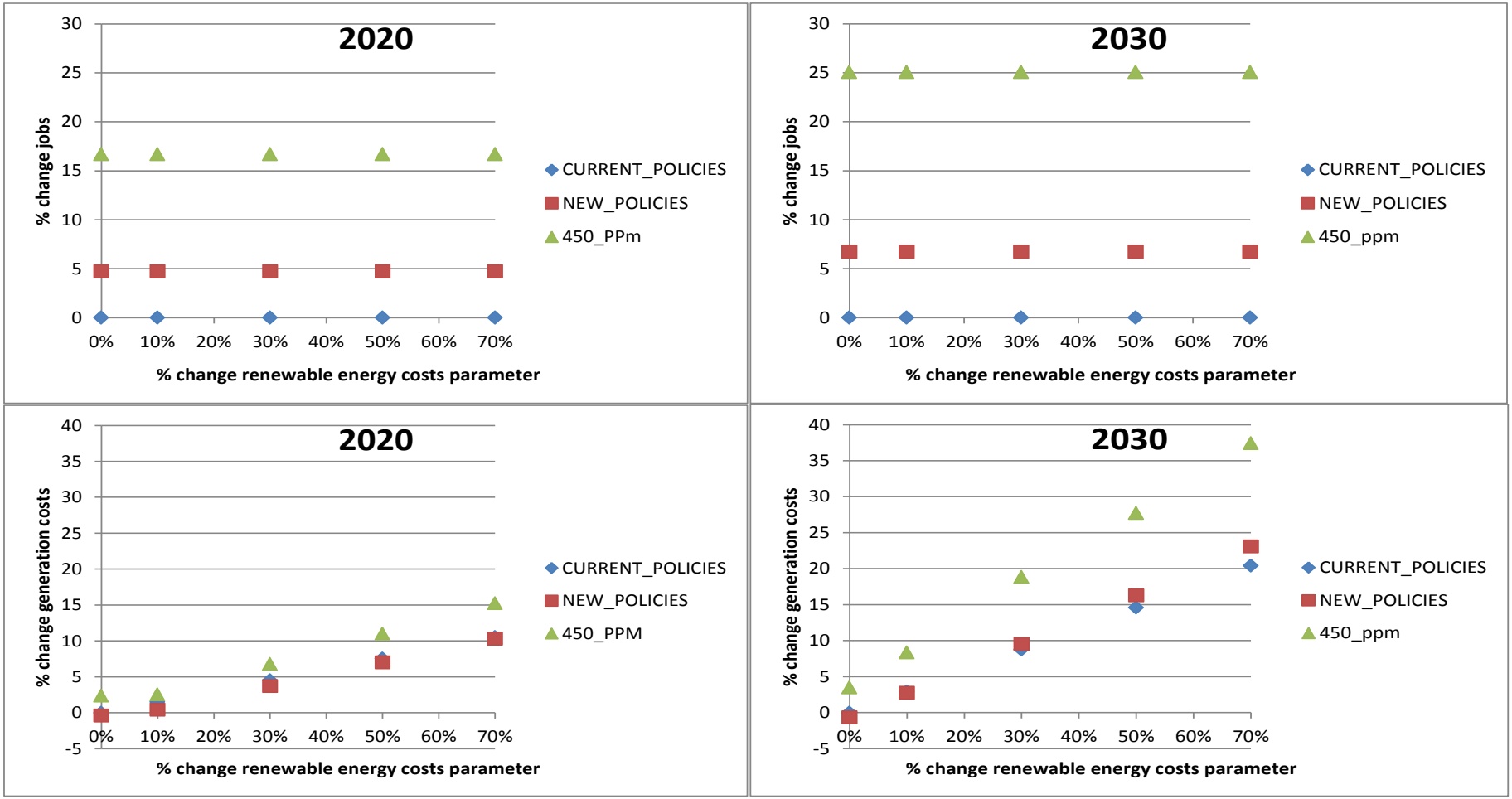
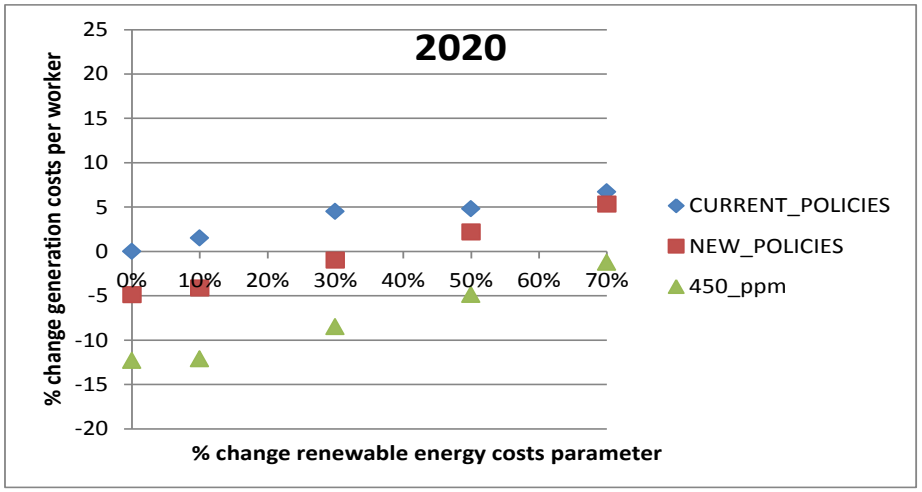
-20
0%
10%
20%
30%
40%
50%
60%
70%
% change leakage parameter
CURRENT_POLICIES
NEW_POLICIES
450_ppm

Figure 10 **Changes deriving from a modification of renewable energy costs relative to the baseline CURRENT POLICY scenario in terms of jobs, generation costs per worker/ year ratio**




2020
% change generation costs per worker
% change renewable energy costs parameter
CURRENT_POLICIES
NEW_POLICIES
450_ppm
25
20
15
10
5
0
-5
-10
-15
-20
0%
10%
20%
30%
40%
50%
60%
70%

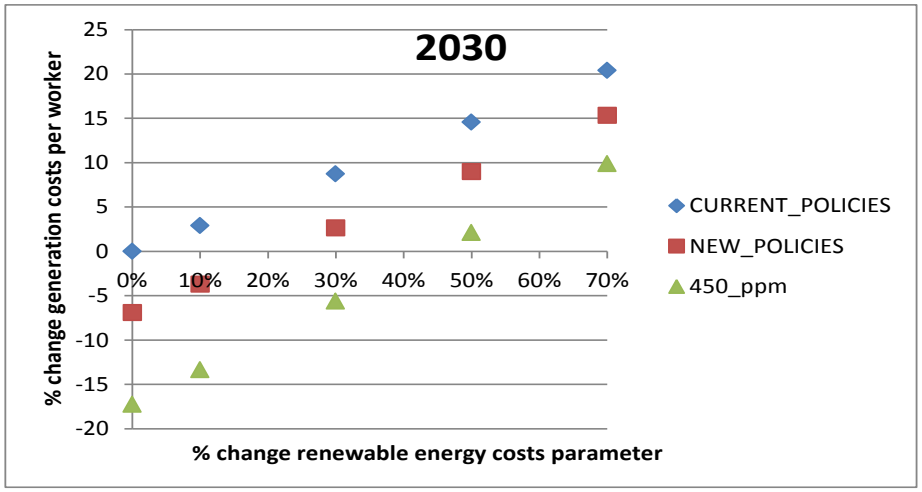
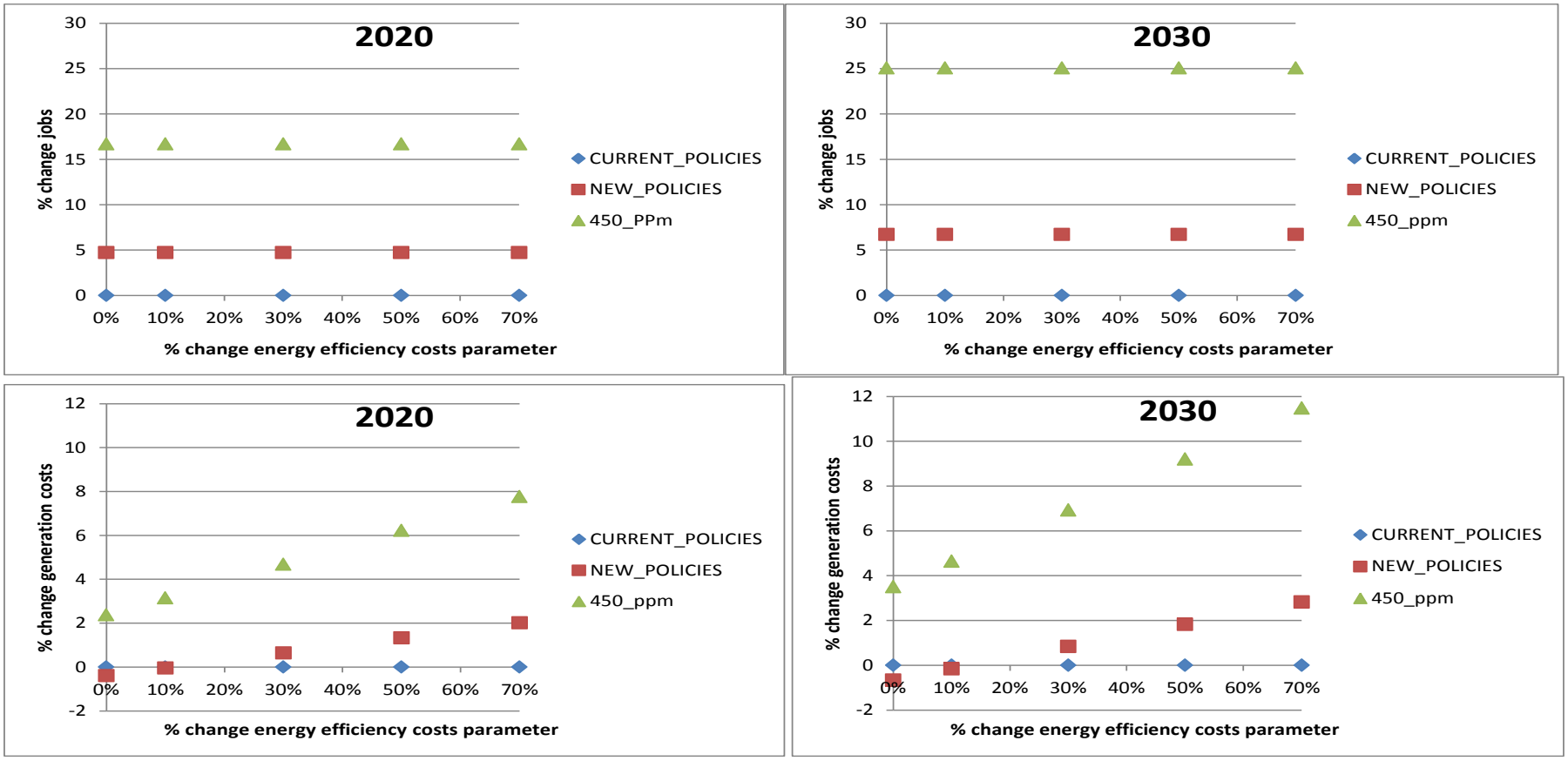
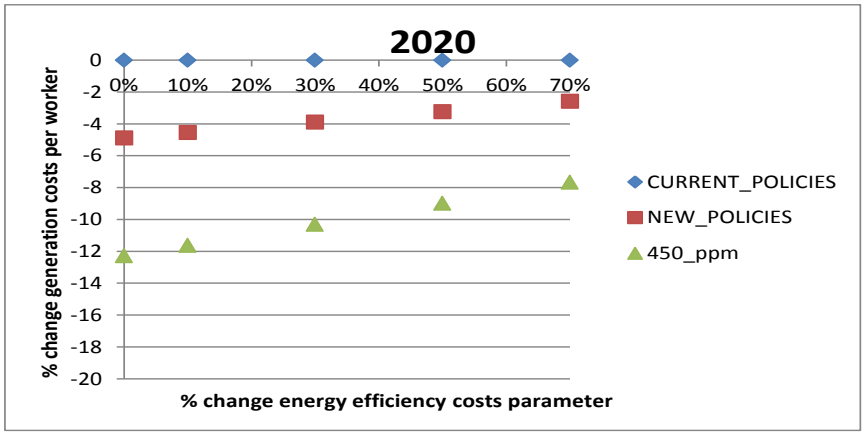
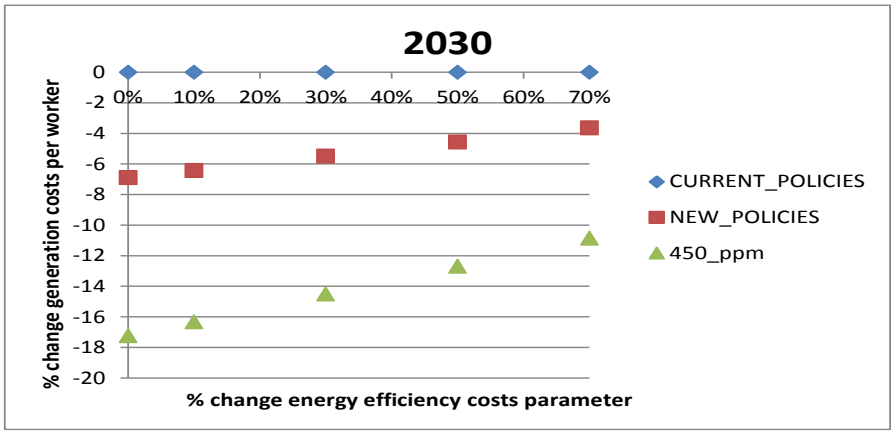

2030
% change generation costs per worker
% change renewable energy costs parameter
CURRENT_POLICIES
NEW_POLICIES
450_ppm
25
20
15
10
5
0
-5
-10
-15
-20
0%
10%
20%
30%
40%
50%
60%
70%

Figure 11 **Changes deriving from a modification of energy efficiency costs relative to the baseline CURRENT POLICY scenario in terms of jobs, generation costs and generation costs per worker/ year ratio**




2020
% change generation costs per worker
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
0%
10%
20%
30%
40%
50%
60%
70%
% change energy efficiency costs parameter
CURRENT_POLICIES
NEW_POLICIES
450_ppm


2030
% change generation costs per worker
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
0%
10%
20%
30%
40%
50%
60%
70%
% change energy efficiency costs parameter
CURRENT_POLICIES
NEW_POLICIES
450_ppm

We also highlight that a simultaneous variation of all parameters may generate dramatic changes in the overall picture. By shifting all the parameters by 10 per cent and 30 per cent, we find that the number of jobs created remain higher in the 450_PPM scenario only up to a 10 per cent variation in all parameters. The generation cost per worker is higher than in the CURRENT POLICY scenario, even with mild shifts for both the NEW_POLICY and 450_PPM scenarios.

Table 4 Changes relative to the baseline scenario CURRENT_POLICY in terms of jobs, generation costs deriving from an increase in energy efficiency costs, renewable energy costs, technology and leakage parameters

	Jobs	Generation costs	Generation costs per worker/ year ratio
current policy all 10%	-3.92	2.92	7.11
new policy all 10%	-3.56	3.25	7.06
450 ppm all 10%	6.18	9.55	3.17
current policy all 30%	-9.63	2.92	20.34
new policy all 30%	-9.30	3.25	24.36
450 ppm all 30%	-0.14	25.84	26.01

5. Conclusion

According to our analysis, a transition towards low carbon power generation in Africa would lead to additional jobs, but with a potential trade-off in terms of electricity generation costs. Energy savings do not always compensate for a higher cost of RE. From a societal perspective, the results are quite robust and indicate that policy actions for a higher penetration of RE and EE generate a social dividend in terms of additional employment together with lower costs of generation per additional employee. Higher costs of renewable energy and employment creation may affect this positive prospect.

The study adds an additional insights into the debate on the desirability of RE and EE for economic, social and environmental sustainability in low/middle income countries. In particular, the results of this paper reveal that if RE become a competition for fossil fuels and if at the same time technologies for EE start becoming less expensive, there is a potential that the greening of the economy favourably impacts all three pillars of sustainable development simultaneously. If costs were to decrease slowly, the higher bill for RE and EE could be compensated by environmental improvements and may make cost effective contributions to unemployment reduction in terms of societal costs. From a policy perspective, these results suggest justification for a fuller integration of green technologies beyond the traditional boundaries of environmental policy.

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Annex I IEA energy balance for Africa in 2009

	Electricity	Heat
	Unit: GWh	Unit:TJ
Coal and peat	250089	
Oil	79217	
Gas	185582	
Biofuels	769	
Waste	0	
Nuclear	12806	
Hydro	101257	
Geothermal	1354	
Solar PV	26	
Solar thermal	0	
Wind	1675	
Tide	0	
Other sources	47	
Total production	632822	513

Annex II Electricity generation costs – WITCH model (Bosetti et al., 2006) cUSD/kwh - 2002

Year 2002	Coal	oil	Gas	Nuclear	Hydro	W&S
MENA region	4.3	4.5	2.8	6.4	5.6	9.5
SSA region	4.1	8.8	3.4	6.2	5.4	9.2

Year 2030	Coal	oil	Gas	Nuclear	Hydro	W&S
MENA region	4.8	5.4	2.6	5.8	4.7	7.0
SSA region	4.9	11.0	3.2	5.9	4.8	7.0

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