Non paper on complementary economic modelling undertaken by DG ENER regarding different energy policy scenarios including updated renewable energy technology costs in the context of Council and Parliament discussions of the recast of the renewable energy directive and the revision of the energy efficiency directive

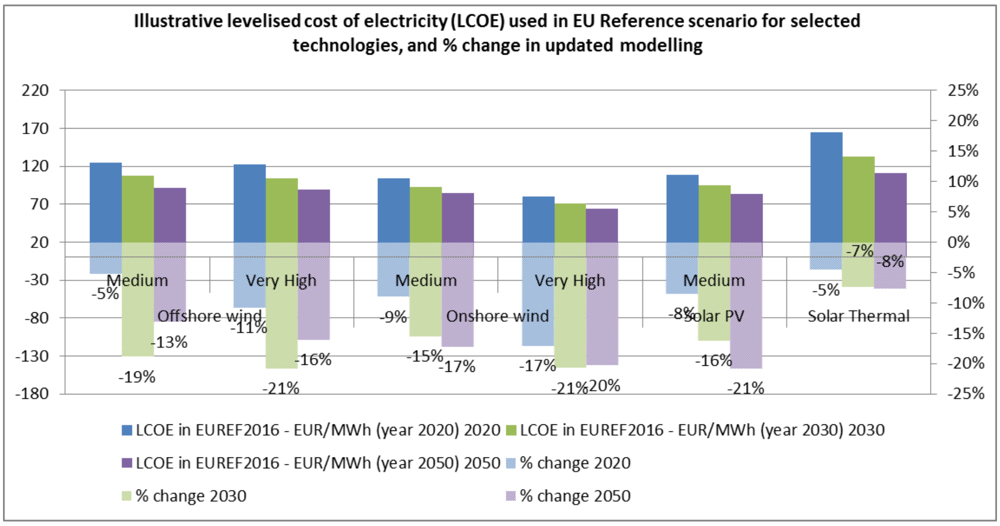
Detailed modelling analysis

This non-paper contains the results of an update of the modelling analysis performed by the European Commission in 2016, for the Impact Assessments underpinning the Clean Energy for all Europeans package.

This update encompasses: i/ a revision of assumptions on renewable energy technology costs (for onshore wind, offshore wind, solar PV and solar thermal); and ii/ the impacts of higher RES targets (30%, 33%, 35%, 45%, with efforts taken across *all* sectors, electricity, heating & cooling and transport) coupled with the energy efficiency targets of 30%, 33%, 35% and 40%.

1. Impacts of lower renewable energy technology costs on reaching a 27% renewable energy target

Based on information collected from different sources including inter alia through, e.g. the International Renewable Energy Agency, the International Energy Agency, and industry associations, **technology cost data were updated in the PRIMES model for wind (off-shore and on-shore) and solar (PV and thermal)** to bring them in line with current technology costs. An illustration of the levelised cost of electricity for such technologies used in the model is presented below, together with the percentage change compared to assumptions used in the EU Reference Scenario 2016, which were based on latest information available at that time.



The levelised cost of electricity (LCOE) for offshore wind in medium potential areas[1] *in 2020 is now €125/MWh, 5% lower than estimated in the 2016 Reference Scenario. The same technology in 2030 has an estimated cost of €108/MWh, 19% lower than previously estimated. And by 2050, the estimated cost would be €91/MWh, 13% lower than previously estimated.*

Lower technology costs make the achievement of a 27% RES target by 2030 (coupled with 40% GHG emission reductions and 30% energy efficiency) **cheaper by 2.9 billion EUR per year in the period 2021-30** and by 6.9 billion EUR per year for the period 2021-2050.

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[1] "Medium" and "Very high" in the chart refer to the wind resource; higher resource often but not necessarily translates into lower LCOE because exploiting them also requires higher investments (e.g. turbines need to be larger).

This is achieved via greater offshore wind and solar power deployment that benefit from lower technology costs in this exercise, while onshore wind and biomass power generation capacity is decreased for the same overall RES deployment level.

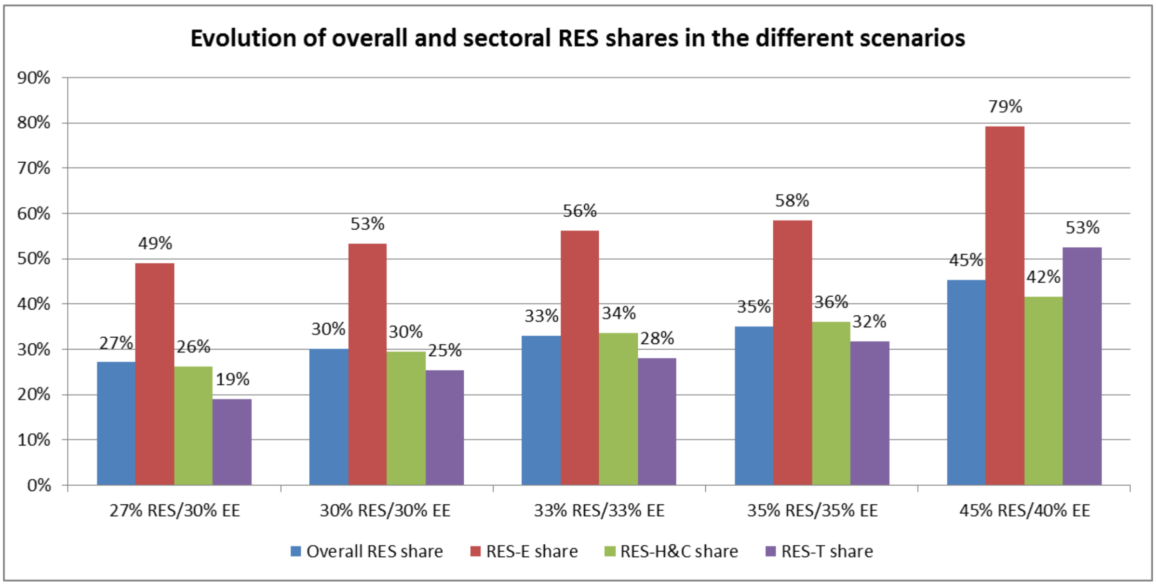
Such lower costs for the energy system are explained by lower investment needs for the same renewable electricity capacity. Overall, **total investment savings in all power generation amount to 14 billion EUR over the period 2021-2030**. Instead of investing 394 billion EUR over the 2021-2030 period, only 380 billion EUR is necessary to reach a similar renewable energy target.

This, in turn, translates into renewable energy support costs passed on to final electricity consumers and electricity prices that are lower by respectively 4% and 0.5%.

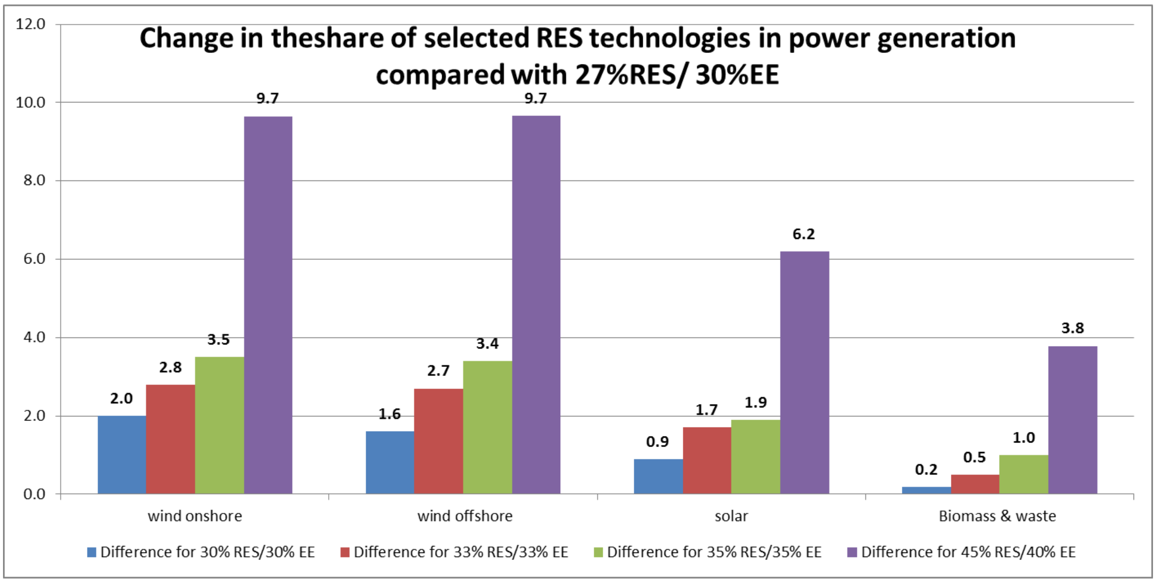
2. Impacts of higher renewable energy targets

(a) Evolution of renewable energy across sectors

The higher renewable targets are achieved by efforts spread across all sectors (power, heating & cooling and transport).



In **power generation**, additional investments in renewable energy technologies are projected in scenarios with higher targets, leading to an **increase in the use of wind (both onshore and offshore), and to a lesser extent solar, in the electricity mix**. The biomass share is stable across the scenarios (until 35%RES/35%EE). Nevertheless, the biomass share increases in the 45%/40% scenario, most likely leading to sharp increases in import needs.

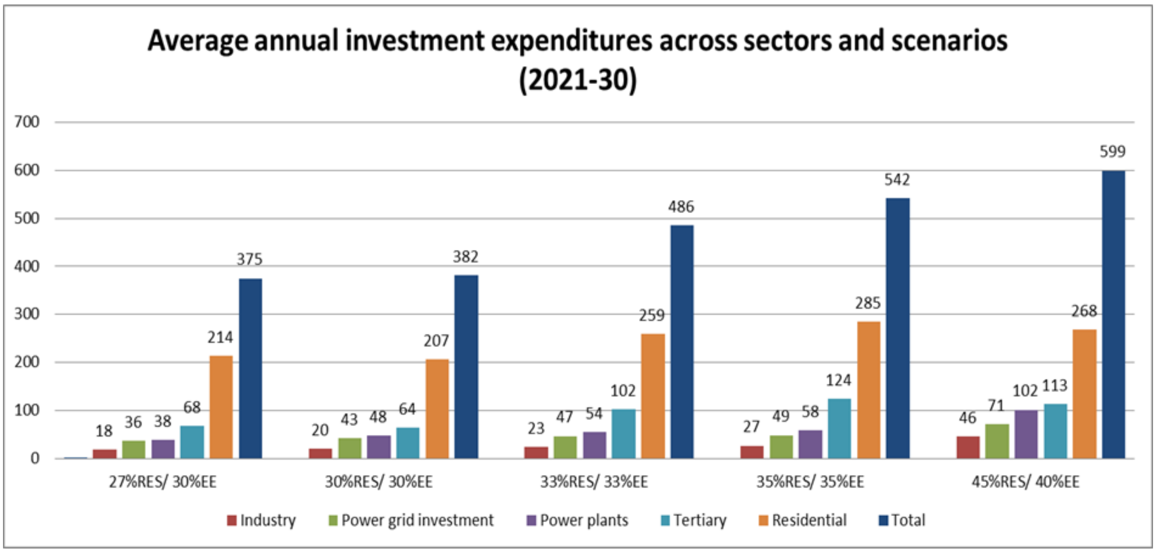


In the **residential sector**, heat pumps deployment is a key contributor to combined renewable energy and energy efficiency efforts. **Renewable energy produced by heat pumps for heating & cooling significantly increases** compared to a scenario with 27% RES with the level of ambition: from +13% in a scenario with 30% RES/30% EE to +122% in a scenario with 45% RES/40% EE. In addition, **biomass used in heating (especially in CHP district heating) increases its penetration**.

On the transport side, consumption of biofuels overall slightly increases with higher targets scenarios. More importantly, a shift takes place between food-based biofuels and advanced biofuels, from the 30% RES/30% EE scenario onward. Both the overall renewable energies in transport mandate (6.8% by 2030 in the RES Directive proposal) and the specific mandate for advanced biofuels (3.6% by 2030 in the proposal), are met at the EU28 level[2]. Conversely, the share of **food-based biofuels decreases** below the proposed cap of 3.8%, to 2.4%. **Transport electrification (number of electric vehicles) slightly increases** with the level of ambition as well, with the share of electric vehicles in the total fleet of light-duty vehicles increasing.

It can be noted that investments in residential and tertiary sectors decrease between a scenario with 27%RES/30% EE and a scenario with a 30% RES/30% EE, for the same level of energy efficiency, while they increase in power generation and power grid. This can be interpreted as energy efficiency improvement delivered by renewables in power generation and by heat pumps alleviating some of the needs for renovations.

[2] The RES Directive proposes national mandates, which are approximated at EU level in the modelling.



(b) Impacts on energy system costs

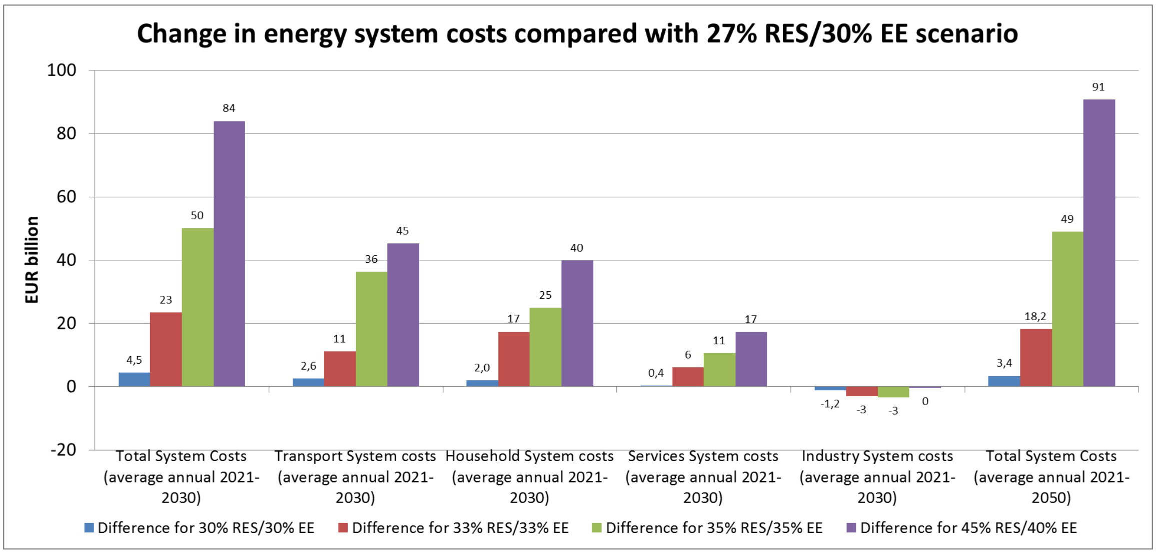
Lower RES technology costs, and a different deployment path of renewable technologies allow **reaching a 30% RES and 30% EE target at system costs comparable** (1.6 billion EUR higher per year which translates to an increase in 0.1% of the total system costs expenditure) **with those estimated in the 2016 Impact Assessment for a 27% target**, while generating additional benefits in terms of GHG emissions and security of supply. The cost is actually €3.5bn *lower* per year when looking over 2021-2050.

More specifically, although investment needs in power generation are projected to increase compared to a scenario with only 27% renewable energy, this increase is somehow balanced by lower technology costs per unit of investment. In addition, the need for public support to promote such investments is also lower. As such, electricity prices remain stable compared to what was estimated in the 2016 Impact Assessment for a 27% renewable energy target, which avoids negative consequences for final electricity users. Costs also decrease in the industrial sector, notably because the ETS carbon price projected is slightly lower. In the residential sector, additional renewable energy technologies options, notably the use of heat pumps, also contribute to limiting the increase in costs.

Even with lower RES technology costs, in the scenarios reaching 33% RES and 33% EE targets, 35% RES and 35% EE targets, as well the 45% RES and 40% EE targets, the total system costs will moderately increase compared to a 27% RES/30% EE scenario.

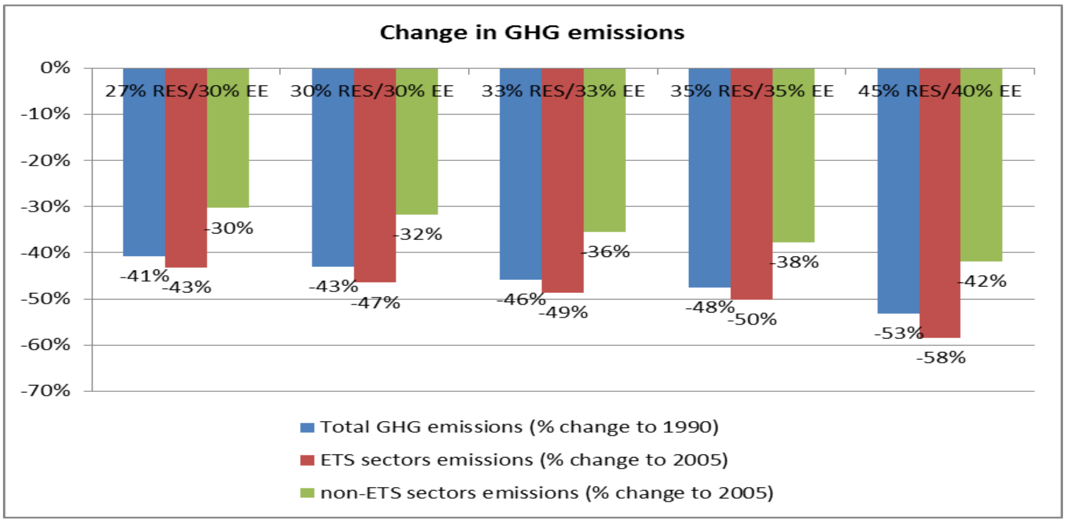
Over the period 2021-30, the total energy system costs increase by € 23.4 bn (1.2%), € 50.1 bn (2.6%) per year and € 84 bn (4.3%) respectively. Over 2021-50, the energy system costs increase by € 18.1 bn (0.8%), € 49 bn (2.2%) and € 90.7 bn (4%) per year. The main drivers of costs increases are investments in power generation which increase by (respectively) €158 bn and €194 bn in the period 2021-30.

Energy system costs increase for all sectors across scenarios, except industry.



(c) Impacts on greenhouse gas emissions and import dependency

Higher renewable energy targets combined with energy efficiency lead to additional greenhouse gas emissions reductions, both in ETS and non-ETS sectors[3], in line with Energy Union objectives. Total GHG emissions decrease from -40.8% in the 27%RES/30%EE scenario to -43% in the 30%/30% scenario, -45.8% in the 33%/33% scenario, -47.5% in the 35%/35% scenario, and -53.2% in the 45%/40% scenario.



At the same time, **import dependency is projected to decrease with a progressive reduction** (from 53.5% in the 27% RES/30% EE scenario to 51.7% in the 30%/30% scenario, 50% in the 33%/33% scenario, 49% in the 35%/35% scenario and 47% in the 45%/40% scenario), with an important reduction in gas imports (27% decrease in the 35% RES/35% EE scenario compared to 27% RES/30% EE, and even 42% decrease in the 45%/40% scenario).

[3] Emissions and removals covered by the land use, land use change and forestry (LULUCF) Regulation are excluded

3. Macroeconomic impacts

An analysis was also performed to assess the macroeconomic impacts of a revision of assumptions on renewable energy technology costs (for onshore wind, offshore wind, solar PV and solar thermal) together with higher RES targets (30%, 33%, 35%, 45%) coupled with energy efficiency targets (30%, 33%, 35% and 40%).

Similarly to what was done in the 2016 impact assessments of the clean energy package, two macroeconomic models were used (E3ME and GEM-E3). and, for each model, two variants were considered. The two variants considered as more realistic are the E3ME "partial crowding-out"[4] and the GEME3 "loan-based"[5] ones and they are the ones presented below.

The expected impacts on GDP of moving to 30% renewables are expected to be overall fairly neutral. For a **30% RES target combined with 30% EE target**, both the E3ME model and the GEM-E3 model show a neutral macroeconomic impact, with marginal changes in GDP.

For a **33% RES target combined with 33% EE target**, the E3ME model suggests potential benefits, with GDP increasing by 0.38% and employment increasing by 0.16% in comparison to EUCO30rev. The GEM-E3 model shows a neutral impact on GDP (-0.03%) and a positive impact on employment (+0.15%).

Looking at the more ambitious scenario of **35% RES target combined with 35% EE target**, the trends described above are generally observed with a greater magnitude. Regarding GDP, the GEM-E3 model foresees a neutral impact (-0.08%). The E3ME model foresees GDP benefits (+0.14% compared to the 27% RES and 30% EE scenario). However, the effect tends to be lower than for a 33% RES target combined with 33% EE target. This lower positive effect is due to the fact that the amount of investments needed to achieve the 35%RES/35%EE targets affects other economic activities due to crowding-out effects.

In the **45% RES target combined with 40% EE target** scenario, according to the E3ME model, the even higher level of investment brings again more positive dynamics in the economy, as the benefits of higher investments autonomously compensate for the negative impacts of crowding-out. This highlights that crowding-out effects are modelled in a non-linear manner (leading to non-linear impacts seen in **35%RES/ 35%EE scenario**). This results in a +0.55% increase in GDP relative to the 27% RES and 30% EE scenario. In the GEM-E3 model the GDP impacts are negative.

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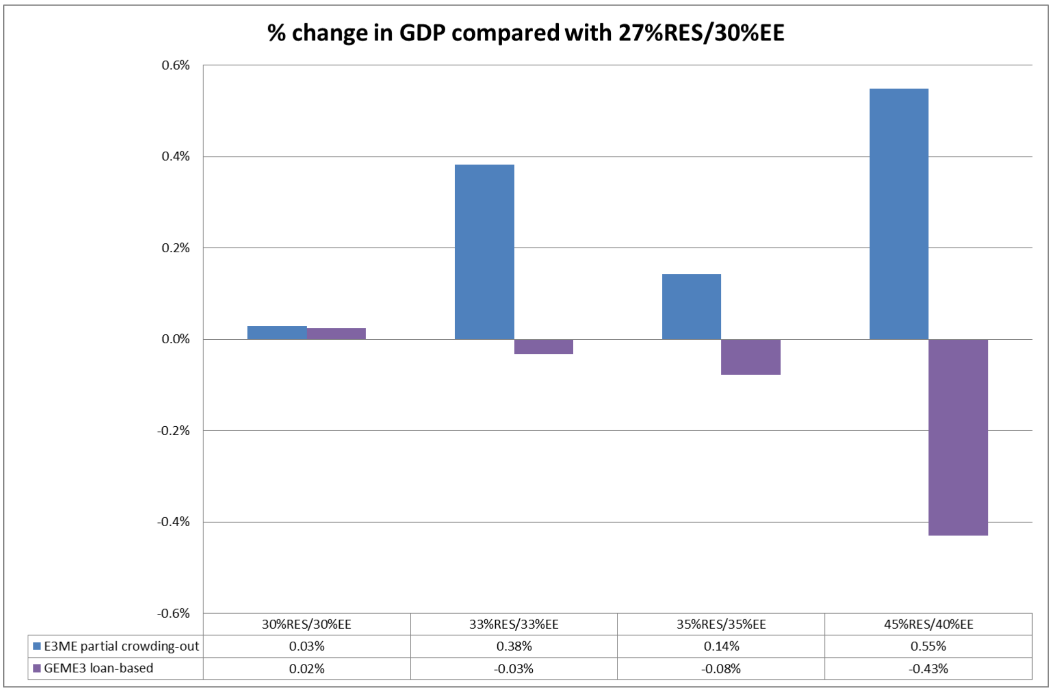
[4] The "no crowding out" represents the standard approach in E3ME and its usual treatment of investment dynamics, whereby there is no maximum level imposed on production growth. Industries can grow by absorbing investments without negatively impacting other sectors (e.g. drawing on spare capacity or unutilised physical capital). The "partial crowding out" imposes a constraint on activity expansion by introducing a rule that would set a maximum amount that the sectors would be allowed to increase by, without adversely affecting other economic activities.

[5] In the "loan-based" finance version, by assumption, an energy efficiency investment in 2020 would be financed via a loan which would cover 90% of total expenditure in 2020. This share is assumed to decrease after 2020, reaching 70% of total expenditure in 2035. Afterwards the percentage remains constant. The loan lasts for 10 years and repayment starts one period after it is issued. In the "self-financing" version, GEM-E3 excludes the possibility of firm and household indebtedness and assumes that all expenditures are self-financed by the sectors undertaking the energy efficiency investments, e.g. firms increase prices, households reduce other expenditures.



As for **employment**, the impacts are linked to those of GDP described above and are also affected by changes in the sectoral composition and the labour intensity of the different sectors. Very limited impacts are expected from moving to 30% RES. In E3ME in the **30% RES and 30% EE scenario**, a small contraction in employment is registered due to lower investments in energy efficiency. Since a significant proportion of the energy-efficiency investment feeds into construction sector activities, which is a big employer, the lower energy-efficiency investment levels are projected to lead to lower employment in the construction sector. For higher targets scenarios, employment impacts broadly follow GDP trends. However, it is worth noting that positive impacts are expected from the GEM-E3 model, even if GDP impacts are slightly negative. This can be interpreted by higher labour intensity of renewable energy and energy efficiency investments, compared with the replaced investments.