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Co-benefits of Climate Action: **Assessing Turkey's Climate Pledge**

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Contents

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For full methodologies and project background, see: *NewClimate (2015) Assessing the missed benefits of countries' national contributions.*
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Introduction

During a ceremony held in New York on April 22, 2016, 175 countries – including Turkey – signed the Paris Climate Agreement, which draws the framework of the new global climate regime. Signatories of the Paris Agreement accepted the goal to keep global average temperature increase under 2°C and to work towards the goal of limiting it to 1.5°C, and recognized the need of a reduction to zero CO_2 emissions during the second half of the 21th century.

Turkey's GHG emissions rose from 207.8 $MtCO_2e$ in 1990 to 467.6 m $MtCO_2e$ in 2014[1]. While Turkey needs to urgently cap its emissions and return to 2010 levels by 2030, the INDC Turkey submitted in 2015 allows for an additional emission increase of 461 m $MTCO_2e$, showing that the Turkish economy will become even more dependent on fossil fuels in the future.

For the fight against climate change to be successful, many sectors – primarily energy, construction and transportation – need to go through a transformation. The short and mid-term costs from this transformation are estimated to be low compared to climate change related financial risks and the benefits that will be achieved through the transformation. The necessary transformation is expected to bring co-benefits such as the continuity of ecosystems and biodiversity, preservation of public health, increase in qualified and clean jobs, reduction on a global as well as national level of foreign-source dependency particularly for energy.

This report prepared by New Climate Institute and with Climate Action Network Europe's contribution, aims at identifying for Turkey the co-benefits of policies compatible with the fight against climate change throughout the sections on job creation, public health and dependency on energy imports. The analysis shows that if Turkey adopts a pathway that prioritizes renewable energy and energy efficiency in line with the 1.5°C and 2°C targets, it can considerably reduce energy import dependency, can create tens of thousands of qualified jobs in the renewable energy sector and can prevent thousands of premature deaths from air pollution.

While this report only demonstrates the co-benefits of the transition to 100% renewables in the energy sector using available and up-to-date data, we should also bear in mind that a report that covers all sectors, written when current data from energy-extensive sectors such as transportation and construction become accessible, could exhibit an important increase in co-benefits.

Climate change is one of the most important problems this planet has ever faced. If we fail to achieve the transformation pointed out by science while we still have time, we know that the negative impacts on nature and humans will be irreversible. In the aftermath of the Paris Agreement, multilateral discussions on the policy measures and practices that will be implemented in Turkey to combat climate change need to increase, expand and diversify.

We wish that the analysis results we share with you will serve as a signal flare for more detailed analyses and enlighten climate change policy experts and decision makers of Turkey.

1 LULUCF not included

Assessing the achieved and missed benefits of Turkey's Intended Nationally Determined Contribution (INDC)

In September 2015, Turkey submitted its Intended National Determined Contribution (INDC) which included a greenhouse gas reduction target of up to 21% below business as usual (BAU) by 2030 including land use, land use change and forestry (LULUCF) (Republic of Turkey 2015). Excluding LULUCF emissions, this target is equivalent to a near four-fold increase on 1990 levels, and is more than double 2012 levels. Under the official reference scenario, Turkey's emissions are expected to nearly triple to 1,175 $MtCO_2e$ in 2030 from 447 $MtCO_2e$ in 2012 (Turkish Statistical Institute 2015). Full implementation of Turkey's INDC target would then reduce national GHG emissions by up to 246 $MtCO_2e$ in 2030. In comparison to a current policies trajectory in 2030, according to our illustrative method, Turkey's INDC would:

- Reduce fossil fuel dependency by at least 13 Mtoe/a, generating annual cost savings from reduced fossil fuel imports of approximately USD 6 billion.
- Prevent in the order at least 7,000 premature deaths each year from air pollution.
- Create approximately 9,000 new jobs in the domestic renewable energy sector.

If Turkey strengthened its INDC to meet a trajectory towards 100% renewables by 2050 (and thus in line with keeping global warming below 2°C and possibly even 1.5°C), it could, according to our illustrative method, achieve the following benefits:

- Reduce fossil fuel dependency by at least 41 Mtoe per year additional to the INDC reductions, entailing annual cost savings of approximately USD 17 billion, in total USD 23 billion compared to the current policies scenario, equivalent to approximately 3% of Turkey's GDP in 2014.
- Prevent in the order of up to 27,000 premature deaths each year from air pollution additional to the INDC improvement, in total 34,000 deaths fewer than in the current policies scenario.
- Create approximately 55,000 jobs in the domestic renewable energy sector additional to the INDC scenario, in total 64,000 more jobs than in the current policies scenario.

A wide range of further co-benefits may be achieved through developing in line with a 2°C or 1.5°C trajectory, including but not limited to improved health of ecosystems, enhanced biodiversity, enhanced mobility and safety in transport, enhanced comfort and reduced operational costs in buildings. However, these benefits are not analysed for this report, which focuses on cost savings from reduced fossil fuel imports, premature deaths from ambient air pollution, and creation of jobs in the renewable energy industry.

Cost savings from fossil fuel imports

Turkey remains very reliant on fossil fuel combustion for energy supply. Energy demand has increased rapidly over the past two decades, particularly in response to a rapidly expanding commercial sector. Meanwhile, fossil fuels accounted for 90% of the country's total primary energy consumption in 2014 (Ministry of Energy and Natural Resources 2015). However, Turkey's own fossil fuel resources are limited, and imports of up to 83% of total primary energy needs are required to meet the country's energy demand (Euracoal 2013). The energy sector in Turkey was responsible for over 70% of the country's total 440 $MtCO_2e$ emissions in 2012 (Republic of Turkey 2015a). Decarbonisation of energy and improvements in energy efficiency can bring significant benefits through cost savings from reduced fossil fuel imports. Energy efficiency improvements can also increase the competitiveness of industries. These potential economic gains are significant, but are not analysed within this study. In this section, the cost savings from fossil fuel imports are presented including coal for the power sector, oil for transport, and natural gas across all sectors.

Coal in the power sector

Consumption of coal is experiencing an upwards trend in Turkey, having more than doubled between 1990 and 2012 (Algedik 2015). In 2014, 58% of coal consumption ensued in power plants, while coal accounted for 30% of electricity generation (Ministry of Energy and Natural Resources 2015). 44% of Turkey's coal consumption was met by domestic production in 2014, whilst the majority was imported from Russia, Colombia, the United States and South Africa.

By 2030, the total electricity generation of Turkey is expected to increase from 252 TWh to approximately 580 TWh, whilst the share of coal is projected to increase from 30% to 32% (WWF & BNEF 2014). Official government plans indicate that the increase in coal-fired generation will be largely met by major increases in lignite power generation, with official estimates indicating that the installed capacity for lignite fuelled plants will grow from 9.3 GW in 2014 to over 20 GW in 2030 (WWF & BNEF 2014). Observers report that such an expansion of lignite generation would constitute an environmental catastrophe for Turkey, as well as increase emissions significantly. Moreover, third party analysis indicates that these lignite ambitions are unlikely; WWF & BNEF (2014) project that hard coal will fuel the majority of the increase in coal powered generation under a current policies scenario, and this is approximately in line with projections up to 2025 from Garanti Bank (2015). The third party estimates are taken for the current policies scenario in this analysis. In either case, Turkey's reliance on imports for its coal power generation will increase considerably up to 2030, with significant negative implications for energy security.

FIGURE 1: **Reduced coal demand for power**

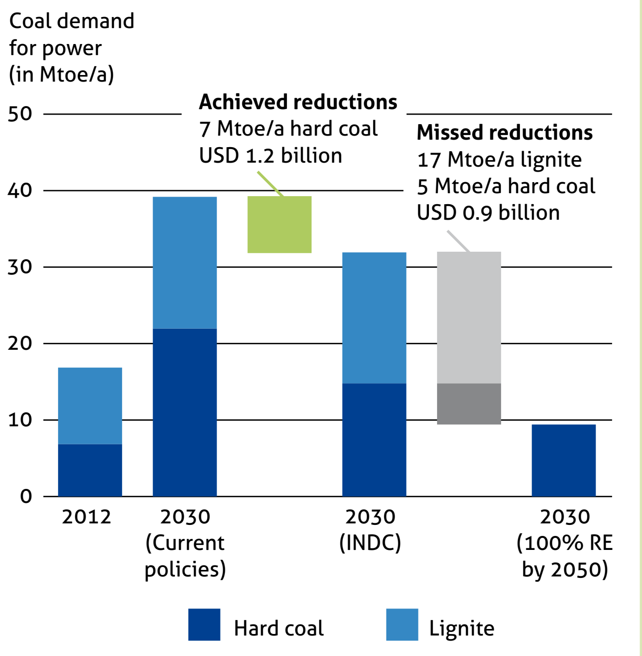


Figure 1 shows how policies and measures for electricity generation that are compatible with the reduction target in Turkey's INDC would reduce coal demand by around 7 Mtoe per year, compared to a current policies scenario; it is assumed that Turkey would chose to reduce reliance on imported hard coal before it reduces its own use of domestic lignite, so this reduction is estimated to entail a cost saving from reduced imports of approximately USD 1.2 billion per year. The reduction could also be met through reductions in lignite demand, which, although not generating direct cost savings from reduced imports, would entail significant benefits for the local environment and for ambient air pollution.

If Turkey strengthened its INDC to meet a 100% renewable trajectory, a further 23 Mtoe reduction per year could be achieved; this scenario presents the case that Turkey would embark on a cleaner trajectory and prioritise the phase out of lignite before hard coal. As such the additional direct cost savings for the reduced imports of hard coal under this scenario are USD 0.9 billion per year, but also with considerable other benefits for the complete phase out of lignite. This 100% renewable trajectory would make a total reduction of 29 Mtoe compared to current policies, and a total saving of approximately USD 2.1 billion.

FIGURE 2: **Reduced oil demand for transport**

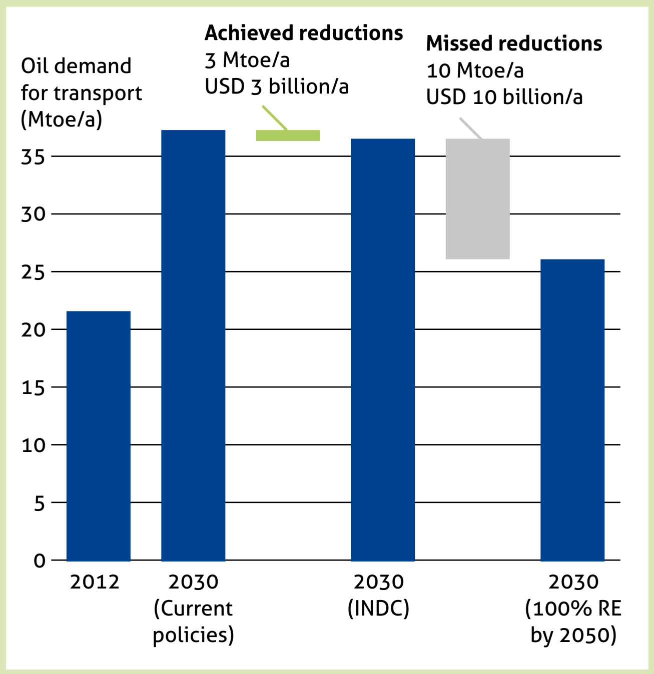
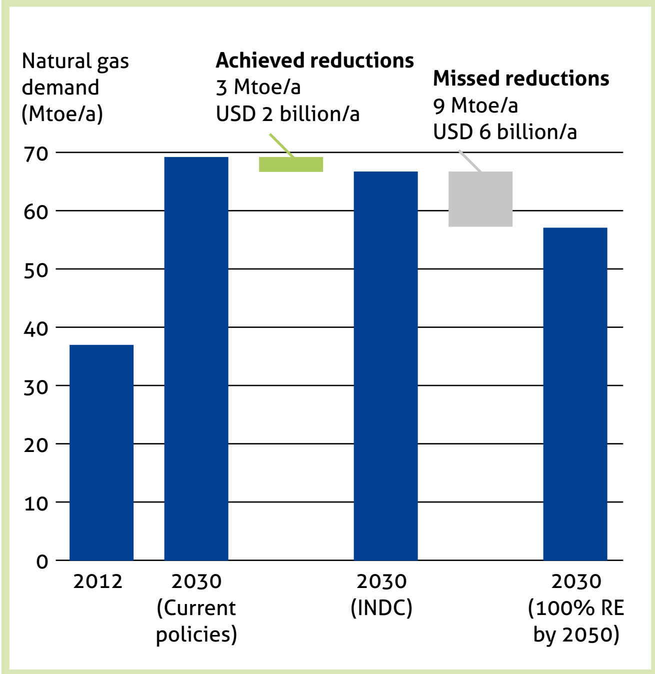


FIGURE 3: **Reduced natural gas demand**



Oil in the transport sector

The transport sector is the major source of oil consumption in Turkey; 98% of energy consumption in transport was from oil in 2014, and transport accounted for 74% of total national oil consumption in this year. Moreover, transport is the only sector in which oil consumption continued to grow significantly since 2000, with its consumption doubling between 2000 and 2014. Only 8% of oil demand in 2014 was produced domestically (Ministry of Energy and Natural Resources 2015).

Figure 2 shows that Turkey's INDC could reduce oil demand from transport by 3 Mtoe in 2030, generating cost savings of approximately USD 3 billion. An additional reduction of 10 Mtoe could be realised if Turkey strengthened its INDC to meet a 100% renewable trajectory, generating cost savings of approximately USD 10 billion, making a total reduction of 13 Mtoe in 2030 (USD 13 billion) compared to under a current policies scenario.

Natural gas

Turkey is highly dependent on natural gas imports; domestic production was at 502 million m^3 in 2014 while consumption was at 48.8 billion m^3 per year. In 2014, natural gas was the major fuel for Turkey's electricity production, accounting for 48% of total generation; electricity generation accounted for about 52% of total natural gas consumption in 2014 (Ministry of Energy and Natural Resources 2015). The remaining consumption of natural gas is split up between the building sector (residential and commercial) and the industrial sector (EIA 2015).

Turkey's current strategy involves rapid expansion of coal-fired generation and coal production to meet the needs of the growing economy and to reduce its dependency on imported natural gas. However, current policy projections still envisage a considerable increase in the total amount of natural gas demand between 2012 and 2030, as indicated in Figure 3. Natural gas is likely to remain a highly relevant energy source in Turkey for the foreseeable future; the regional supply of natural gas may grow and become more competitive due to recent discoveries of potentially large gas resources by nearby countries (Oil Change International 2015).

As Figure 3 shows, Turkey's INDC would reduce gas consumption by 3 Mtoe beyond the current policy scenario entailing cost savings of approximately USD 2 billion. A further reduction of approximately 9 Mtoe, saving a further USD 6 billion, could be possible if Turkey strengthened its INDC to meet a 100% renewable trajectory, making total cost savings of USD 8 billion per year in 2030, compared to under a current policies scenario.

FIGURE 4: **Reduced premature deaths from air pollution**

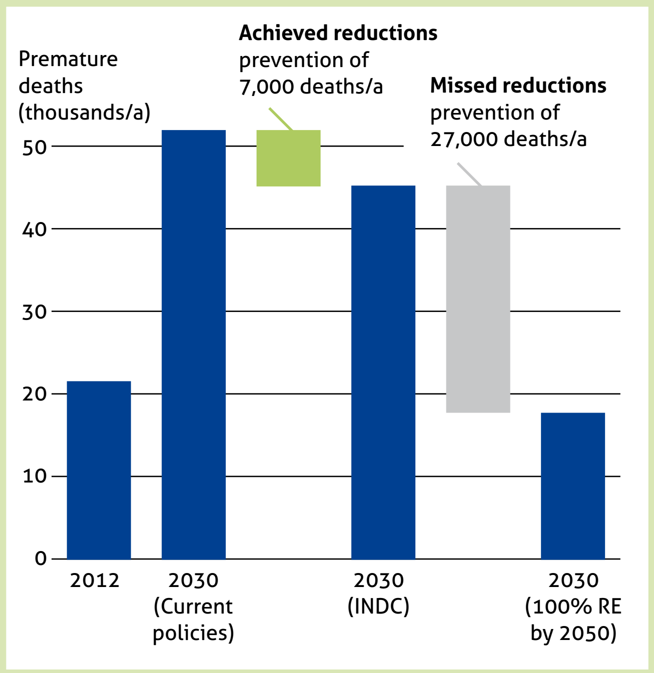
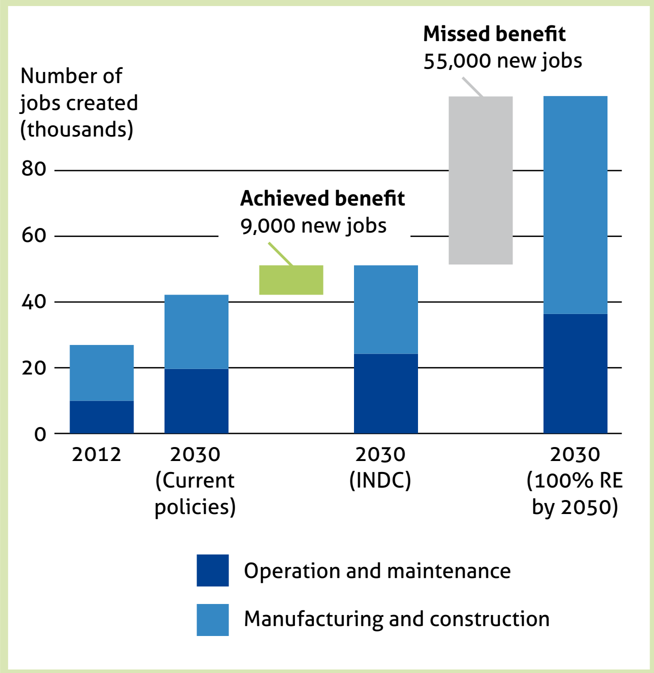


FIGURE 5: **Creation of green jobs for renewable energy**



Premature deaths from outdoor air pollution

In 2013, over 97% of Turkey's total population was exposed to PM2.5 levels exceeding WHO guidelines values, with a mean annual exposure of 17 m g/m^2 (World Bank 2013). Air pollution is especially high in the larger cities, particularly in the three largest metropolitan areas of Istanbul, Ankara and Izmir, where 30% of Turkey's population reside (UNICEF 2013). Major air pollution sources include motor vehicles and coal fired power plants, as well a residential heating due to the poor quality of heating fuels and building insulation (IMM 2009). The Istanbul Air Quality Strategy of 2009 aims to reduce these emissions, while the National Air Quality Observation Network programme of the Ministry of Environment and Urbanization aims to make real time data on air quality available to the public.

Figure 4 shows that the number of premature adult deaths attributable to outdoor air pollution may triple between 2012 and 2030 under current policies, due to deteriorating ambient air quality. New policies and measures to implement the INDC may partially reverse this trend, preventing around 10,000 deaths per year by 2030, compared with the current policies scenario. Strengthening the INDC further to meet a 100% renewable trajectory could prevent an additional 25,000 premature deaths each year, or a total of 35,000 deaths in 2030 compared to a current policies scenario. This would see the level of annual deaths decrease below 2012 levels.

Creation of green jobs in domestic renewable energy

The 2015-2019 Strategic Plan aims to move towards a national renewable energy target of 30% total electricity generated from renewable sources by 2030 (Republic of Turkey 2015b). Observers have claimed that this is a particularly unambitious target, given that renewables already accounted for 31.5% of generated electricity in 2015 (TEİAŞ 2016), although the high reliance on hydro means that this figure was only 20% during the particularly dry year of 2014 (Ministry of Energy and Natural Resources 2015). A shift towards more domestic renewable energy in Turkey would create new jobs in operation and maintenance as well as in manufacturing and construction of the technologies.

According to our methodology, we estimate the creation of approximately 9,000 additional jobs in the renewable energy sector in 2030 under Turkey's INDC scenario, compared to the current policies scenario. The majority of this increase is accounted for by potentially large scale investments in hydro under the INDC scenario. Turkey's INDC indicates that the full technical potential of hydroelectric power should be installed by 2030: the economically exploitable potential is estimated to equate to a capacity of approximately 36 GW (WWF & BNEF 2014). Under the INDC scenario, with installed capacities in 2030 of 10 GW and 16 GW for solar and wind, respectively, our illustrative methodology estimates that there will be approximately 13,000 full time equivalent jobs for solar and 12,000 jobs for wind in 2030. By comparison, there were an estimated 6,000 full-time jobs for wind energy in 2012, whilst employment from solar was negligible. It is noted that there is inconsistency in national renewable energy targets since the projected installed capacities in the INDC are not in line with targets from the National Renewable Energy Action

Plan which proposes capacities in 2023 of 20 GW wind, 5 GW solar, 1 GW geothermal, and another 1 GW biomass.

A further increase of approximately 55,000 jobs in 2030 may be realised should Turkey increase the ambition of the INDC to meet a 100% renewable trajectory. The 100% renewable by 2050 trajectory projects a total installed capacity in 2030 of 41 GW wind, 35 GW solar, 0.4 GW biomass and 1.1 GW geothermal. Under this scenario, employment in the wind and solar sectors could increase to approximately 33,000 jobs for wind and 45,000 jobs for solar in 2030. By comparison, there were an estimated 6,000 full-time jobs for wind energy in 2012, whilst employment from solar was negligible. Under the 100% renewable trajectory, employment in the wind and solar sectors could increase to approximately 21,000 jobs in each sub-sector in 2030. Again, these estimates in the 100% renewable scenario assume a large role for hydro-electricity. Should hydro-electricity capacity be capped at 34 GW (the forecast capacity in 2023 according to the obligatory targets of the 2023 Renewable Energy Strategy), the contribution of wind and solar under the 100% renewable scenario would be greater, leading to approximately 38,000 jobs in the wind sector in 2030 and 37,000 jobs in the solar sector. Many stakeholders argue for a cap on large scale hydro due to the potentially vast negative implications that such projects can have for social upheaval, environmental degradation and resilience to climate change impacts.

Comparison with other countries

Figure 6, Figure 7 and Figure 8 present the results of the analysis compared to other countries, including South Africa, China, Chile and India. In these charts, the results are presented on a per capita basis on order to compare the respective impacts of each potential benefit across the countries, relative to their population sizes. Per capita calculations are based upon the projected populations in each country in 2030, according to the World Bank Health Nutrition and Population Statistics (World Bank 2015).

FIGURE 6: **Turkey's potential cost savings for fossil fuel imports, compared to other countries (USD per capita)**

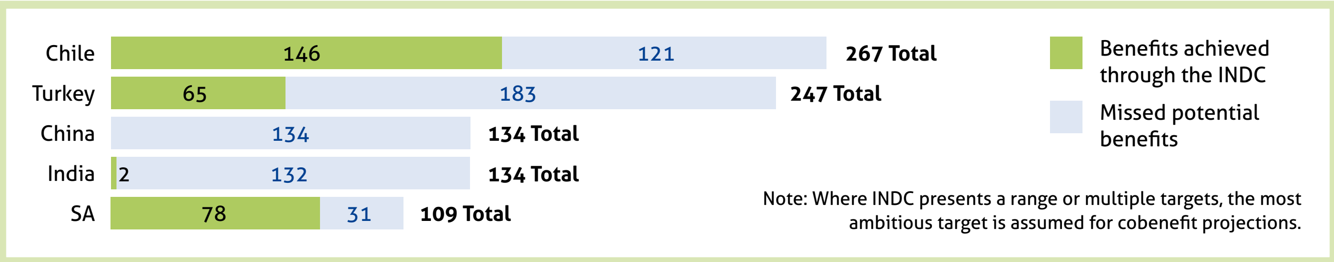


FIGURE 7: **Turkey's potential reduced premature deaths for air pollution, compared to other countries (prevented annual deaths per million people)**

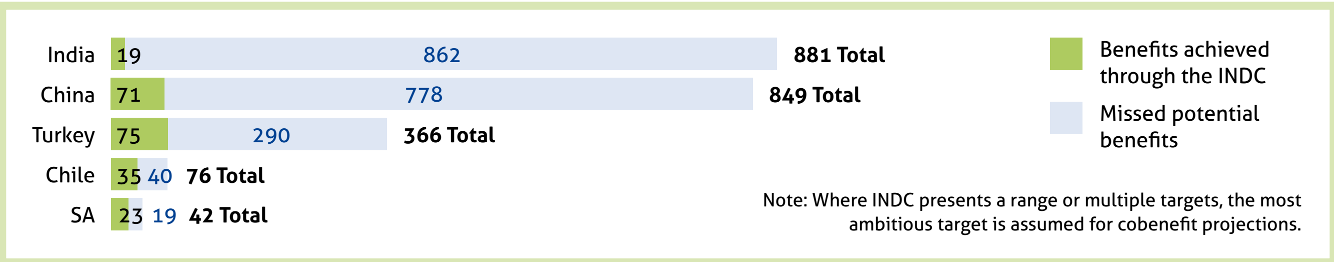
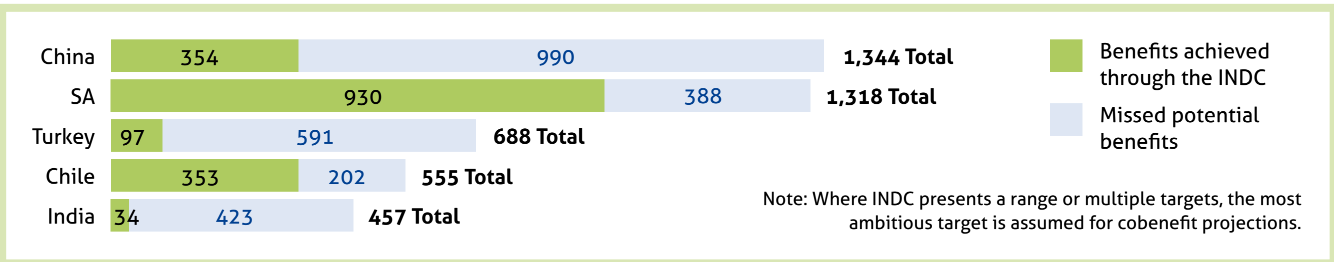


FIGURE 8: **Turkey's potential job creation for renewables, compared to other countries (full-time equivalent jobs in addition to current policies scenario, per million people)**



Conclusion

According to its 2023 vision, Turkey, a member of G20 and OECD, aims to become one of the top ten economies in less than ten years. In the current global conjuncture, some major emerging economies have become more and more aware of the benefits of cutting GHG emissions. It is now clear that the costs of shifting to a low-carbon economy will be far less than the human and monetary costs of the severe impacts, the global climate crisis will bring.

Moreover, by shifting to a low-carbon, 100% renewable pathway, fastly emerging economies like Turkey will benefit from a strongly reduced dependency on fossil fuel imports, will save lives through reduced pollution and will create more sustainable, green and qualified jobs that could have a major positive impact on the country's developmental vision.

Turkey has a relatively high current account deficit[3], and a big part of this occurs due to its dependence on energy imports. Given the costs and relatively low-skilled labor nature of the lignite and coal industry, investments in renewables would have the highest value-added results, both directly and indirectly. Increasing its investment in sustainable, renewable energy resources, would promote broad economic benefits that would include more technology-intensive, high-skilled, qualified and better-paying jobs which would help the country develop a skilled job market[4]. The report clearly shows that if Turkey had an ambitious INDC, setting the country on a trajectory towards a 100% renewable electricity market by 2050, the country would **reduce its fossil fuel dependency by at least 54 Mtoe per year entailing annual cost savings of about USD 23 billion** compared to the current policies scenario, equivalent to approximately 3% of Turkey's GDP in 2014. In addition to this significant drop in dependence on fossil fuel imports, around **64,000 new jobs** would be created in the domestic renewable energy market.

Under current policies, the number of premature adult deaths attributable to outdoor air pollution in Turkey may triple between 2012 and 2030, due to the deterioration of the ambient air quality. Emissions from fossil fuel based energy production in Turkey contribute significantly to diseases from air pollution. Recent research shows that air pollution in Turkey leads to 2,876 premature deaths, 3,823 new cases of chronic bronchitis with adults, and 4,311 hospital admissions per year[5]. This report demonstrates that strengthening the INDC further to meet a 100% renewable trajectory could **prevent a total of 35,000 deaths in 2030** compared to the current policies scenario. This would see the level of annual deaths decrease below 2012 levels.

Globally, investment in solar, wind and energy-efficient technologies is rising and this energy transformation is happening fastest in emerging economies. **China and India are at the limits of their coal-fired generation because of the unacceptable levels of air pollution it creates, while the growth of renewables in China, India and in several other emerging economies is exceeding government expectations.** In the this report, the achieved and missed benefits of certain emerging economies such as China, India, Chile, South Africa and Turkey in terms of their submitted INDCs are compared. It can be clearly seen in the figures that if Turkey would achieve the potential benefits that it is now missing based on its current weak INDC, the country can have a significant leap to reach its development objectives.

3 http://www.tepav.org.tr/upload/files/1426001674-9.An_Investment_Policy_Framework_for_Turkey_in_the_Twenty_First_Century.pdf

4 http://ieefa.org/wp-content/uploads/2016/09/Turkey-Crossroads-Invest-in-the-Old-Energy-Economy-or-the-New_June-2016-v2.pdf

5 http://env-health.org/IMG/pdf/19052015_hr_coal_report_turkey_final.pdf

Supplementary information

See Annex II for methodology and cross country assumptions.

Mtoe: Million tonnes of oil equivalent. 1 Mtoe = ca 1.11 billion m^3 natural gas, 1,428 million tonnes coal equivalent.

Assumptions for Turkey

Relationship to World Energy Outlook regions: In some cases, trends are estimated based upon the current policy and 450 scenarios of regions from the World Energy Outlook. Where such relationships are used, further information is given in the assumptions listed below. Turkey belongs to the G20 and the OECD Europe groups. However, due to the wide variety of countries in these groups, the average trends for these groups are not considered a probable reflection of likely trends for Turkey. In terms of the current policy outlook for the increase in emissions and total primary energy supply, the WEO Middle East region appears to be the best reflection of the Turkish situation[2], and is normally used where relationships to WEO trends are necessary.

Coal demand: Historical coal consumption data is taken from the Turkish Ministry of Energy and Natural Resources (MENR 2014). The current policies scenario for 2030 is based on BAU trends from the analysis of WWF & BNEF (2014). The results of this extrapolation are in line with other third party projections, such as the Global Subsidies Initiative (GSI 2015). Coal demand under the 100% renewable scenario is estimated based upon a relationship between the emission projections of the Renewables Development Pathway of WWF & BNEF (2014) and the emissions projections of the 100% renewable by 2050 scenario.

Oil demand: 2030 values are calculated based on a relationship to the trends of the World Energy Outlook for the Middle East region (IEA 2015).

Natural gas demand: Current policy projections for demand up to 2030 are based on the projections of Melikoglu (2013), which are in line with the forecasts of the Turkish Petroleum Pipeline Corporation (2014). 2030 values for the 100% renewable scenario are calculated based on a relationship to the trends of the World Energy Outlook 450 scenario for the Middle East region (IEA 2015). Like most WEO regions, this scenario envisages only a moderate decrease in natural gas demand compared to current scenarios, due to the likely role of natural gas as a transition fuel in a decarbonising economy.

2 For extrapolations based on regional data from the World Energy Outlook, the Middle East region was selected over the Eastern Europe/Eurasia region. This selection was made since the projections for the development of energy use and energy related emissions for the Middle East region tend to match the general situation for Turkey better than projections of the Eastern Europe/Eurasia region do.

INDC scenario: This scenario is based on a 21% reduction below BAU levels in 2030, according to the BAU reference indicated in the INDC. The INDC BAU is slightly higher than the emissions assumed under the current policy scenario in this analysis, which are taken from the current policies scenario of the Climate Action Tracker. The 21% reduction is the maximum end of the INDC range (up to 21% reduction), as communicated in Turkey's Intended Nationally Determined Contribution (Republic of Turkey 2015a)

Background Particulate Matter 2.5: The background (naturally occurring) concentration of PM2.5 for Turkey is assumed to be 0.93 ug/m^3 as indicated for the Middle Eastern region in Anenberg et al. (2010).

Determination of energy related emissions in 2030: The energy related emissions trend for the current policies and INDC scenario follows the rate of increase between 2010 and 2030 of total emissions, according to the data from the INDC. The 100% renewable scenario is based on a linear decrease in emissions intensity of energy, along with assumed energy efficiency gains similar to those in the World Energy Outlook 450 scenario for some other countries in the region, and in line with other third party projections (Ministry of Energy and Natural Resources 2014).

Projections for future energy demand and electricity generation: Based on information from the INDC, the Climate Action Tracker, and an extrapolation of analysed trends up to 2030 (WWF & BNEF 2014).

Generation of jobs: Estimation of job generation from renewable energies under current policies and the INDC scenario is based on installed capacities of each renewable technology, taken from the INDC document and from WWF & BNEF (2014) for current policies.

Maximum hydro technical potential: Hydro is assumed to have a maximum economic potential of 36 GW (WWF & BNEF 2014).

Share of renewable technologies under 100% renewable scenario: The share of individual renewable technologies in 2030 is based on the assumption that a 100% renewable power sector in 2050 would include the maximum economically feasible potential for hydro, whilst the remaining generation capacity requirements would be split according to the 2030 non-hydro renewable split in the Renewables Development Pathway of WWF & BNEF (2014).

Oil import prices in 2030: From projections of the IEA World Energy Outlook 2015 (IEA 2015).

References and data sources

See NewClimate (2015) for cross country references and data sources.

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ANNEX I: **Scenarios**

Current policies scenario

The current policies scenario simulates the conditions expected in the country should it continue with its current policies, programmes and measures. This scenario is taken from a combined analysis of sources including national data from the INDC, data from the Climate Action Tracker, and WWF & BNEF (2014).

INDC pathway

The INDC pathways are taken from national data from the INDC, data from the Climate Action Tracker, and interpolations from other scenarios.

100% renewable / 2°C compatible pathway

The 100% renewable pathway defines a trajectory which a country should take if it is to be consistent with the internationally agreed goal to limit global temperature increase to less than 2°C. For the purpose of this study, the scenario is defined upon the following simplified general principles:

- The country reaches 100% renewable energy by the year 2050.
- For energy demand we use the projected trends from WWF & BNEF (2014).
- A linear pathway is followed from the country's current renewable energy shares to 100% in 2050.
- It is assumed that the split between different fossil fuels used for fossil fuel combustion remains constant throughout the phase-out period between now and 2050.

The resulting pathway of energy-related emissions is consistent with scenarios of all greenhouse gas emissions that limit global average temperature increase to 2°C with a very high likelihood and that limit global average temperature increase to 1.5°C with 50% likelihood.

These principles are highly simplified because they neglect the possibilities to achieve a 2°C compatible scenario through other means. For example, countries might continue to increase their emissions in the short term and then reduce them at a faster rate in the future, intermediate shifts to different fuel types (such as a shift from coal to natural gas) might occur before the full phase-out of emissions, or it may become feasible for countries to achieve a 2°C compatible scenario through the use of carbon capture and storage alongside continued fossil fuel combustion. In reality the definition of a 2°C compatible scenario is highly complex; there is no single way to develop on a 2°C compatible trajectory, and the approaches that are most attractive are entirely dependent on the economic and political climate of each individual country. For the sake of clarity and comparability the simplified principles described above will be used for all countries.

The precise calculation of the 100% renewable scenario varies between each co-benefit indicator and is discussed in more detail in the specific methodology section for each respective indicator.

ANNEX II: **Indicator calculation methodologies**

Reduced fossil fuel imports

Defining the indicator and scope

This measurement assesses the cost savings associated with the reduced imports of fossil fuels, due to the reduced demand for these fuels in sectors due to reductions in energy demand and shifts to alternative sources of energy.

For this co-benefit, we consider reduced coal imports for power generation, reduced oil imports for transport, and reduced natural gas demand in all sectors. The selection of these sectors and fuels generally covers the major sources of fossil fuel powered energy consumption, as well as the major sources of potential co-benefit; coal and oil satisfied an estimated 74% of global energy demand in 2013, whilst power accounted for 62% of coal demand and transport for 55% of oil demand. The demand for natural gas worldwide nearly doubled between 1990 and 2012, and is forecast by some scenarios to be the world's greatest source of energy in 2040 (IEA 2014).

Calculation methodology

Output indicators

Table 1 presents the output indicators that will be produced from this methodology. The indicators shaded in light blue are the major output indicators whilst the unshaded rows are the sub-level indicators.

Method of calculation

The production of the output indicators will be based upon a calculation of the differences in energy demand (per sector and fuel type) between the three scenarios: current policies, INDC and 100% renewable. Table 2 presents the required data inputs for the calculation of the co-benefit in year x.

TABLE 1: **Output indicators for reduced fossil fuel imports**

Indicator	Scope	Unit
Cost savings from reduced fossil fuel imports achieved	Combined sectors and fuels	USD per year
Potential cost savings from reduced fossil fuel imports missed	Combined sectors and fuels	USD per year
Reduction of oil/coal/gas imports in the transport/power sector achieved	Per sector and fuel type	Mtoe
Potential reduction of oil/coal/gas imports in the transport/power sector missed	Per sector and fuel type	Mtoe

TABLE 2: **Data inputs for the calculation of reduced fossil fuel imports**

Indicator	Unit	Source
Sectoral fuel demand in year x according to current policies (D_{CP})	Mtoe	Own calculations based on trends from WWF & BNEF (2014), Melikoglu (2013) and IEA (2015)
Sectoral fuel demand in year x according to the INDC pathway (D_{INDC})	Mtoe	Author calculations based on interpolation between scenarios
Sectoral fuel demand in year x according to 100% renewable pathway (D_{2C})	Mtoe	Author calculations based on fuel demands and emission pathways for various scenarios, using data from WWF & BNEF (2014) and IEA (2015).
Domestic fuel production (P)	Mtoe	Energy Balance Tables for 2012 and 2014 (Ministry of Energy and Natural Resources 2015)
Forecast international price of fuel in year x	USD	World Energy Outlook (IEA 2014)

Figure 9 shows that the sub-level indicators are calculated in the following way, assuming 2030 as the target year of the INDC:

$$\textit{Reduction of imports achieved in } 2030 = D_{CP} - D_{INDC}$$

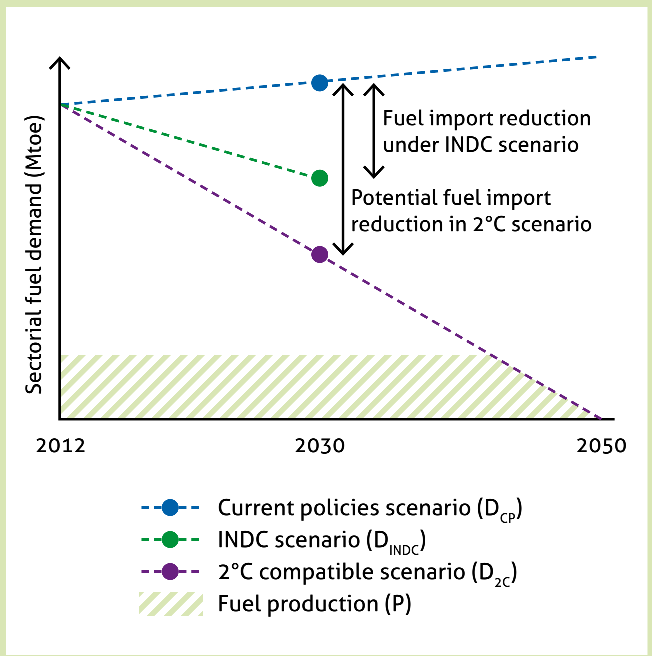
$$\textit{Potential reduction of imports missed in } 2030 = D_{INDC} - D_{2C}$$

These calculations assume that the domestic fuel production remains lower than the fuel demand in the INDC and 100% renewable scenarios. In countries where this is not the case, the calculation of the reduced imports is rather calculated based on the parameter P (fuel production):

$$\textit{Reduction of imports achieved in } 2030 = D_{CP} - P$$

$$\textit{Potential reduction of imports missed in } 2030 = D_{INDC} - P$$

FIGURE 9: **Demonstrative calculation methodology for cost savings from fossil fuel imports (not real data)**



These sub-level indicators may be converted to the primary output indicator (cost savings) by applying a simple conversion formula based on the international fuel price:

$$\textit{Cost savings from reduced fossil fuel imports achieved} = \textit{Reduction of imports achieved} \times \textit{International price of fuel}$$

$$\textit{Potential cost savings from reduced fossil fuel imports missed} = \textit{Potential reduction of imports missed} \times \textit{International price of fuel}$$

Reduced air pollution

Defining the indicator and scope

This methodology assesses the health impacts of decreased outdoor air pollution in urban conurbations, due to the reduced combustion of fossil fuels.

This study considers the health impacts associated with reduced ambient atmospheric concentration of PM2.5 in urban and rural populations (using national averages), based upon reduced emissions of primary particulate matter (PM), sulphur dioxide (SO_2), non-nitrogen oxides (NO_x), and ammonia (NH_3), from all sectors.

PM2.5 refers to particulate matter with a diameter less than 2.5 µm. PM2.5 is the most lethal outdoor air pollutant in urban areas (OECD 2011). Its atmospheric concentration is derived from the emissions of primary particulate matter from fossil fuel combustion processes, as well as from atmospheric reactions between other pollutant gases (secondary particulate matter), namely SO_2, NO_x, and NH_3.

Concentrations of PM2.5 in any given location can be derived from five distinct sources: natural sources of particulate matter including dust and sea salt; secondary PM from international transboundary emissions; primary and secondary PM from national emissions; primary and secondary PM from urban emissions; and primary PM from street emissions. Natural sources of PM cannot be affected by the domestic policy. The calculation of PM concentrations from international transboundary emissions would require a more in depth version of an air transport model. Therefore, the simplification is made that due to the size of the land masses, most areas are subject to only domestically produced anthropogenic GHG concentrations. As such, policy scenarios are reflected equally in all source components of PM2.5 concentrations, except for the natural source component which remains constant throughout.

This indicator will only reflect the number of premature deaths per year, and as such it considerably underestimates the impacts on human health and the related costs from non-lethal conditions such as chronic and acute bronchitis, or asthma.

Calculation methodology

A large number of studies and models exist which calculate local air pollution and associated health impacts. These methodologies vary considerably with regards to their complexity and accuracy. Indeed, the precise determination of local air pollution is a highly complex exercise that is largely dependent on a very wide range of variables, including local climatic conditions as well as geographical features and urban topographies. For this study, simplified methodologies were combined and adapted to suit the requirements of the output indicators.

Output indicators

Table 3 presents the output indicators that will be produced from this methodology. The indicator shaded in light blue is the major output indicator whilst the unshaded row is the sub-level indicator.

Method of calculation

The calculation of the output indicators is based upon the differences in the emissions between the three scenarios (current policies, INDC and 100% renewable), and a selected response factor to calculate PM2.5 concentrations and associated deaths. Table 4 presents the required data inputs for the calculation of the co-benefit in year x.

TABLE 3: **Output indicators for reduced air pollution**

Indicator	Unit
Number of premature deaths saved per year due to reduced PM2.5 concentrations.	Deaths per year Percentage change
Reduced national average exposure to PM2.5 concentrations due to reduced emissions of greenhouse gases	µg/m³

TABLE 4: **Data input for the calculation of reduced air pollution**

Indicator	Unit	Source
Mean annual exposure to PM2.5 concentrations in the year 2012 (G_{2012})	µg/m³	World Development Indicators (World Bank 2013)
Estimated national average background concentration of PM2.5 from natural sources (G_N)	µg/m³	Based on Anenburg et al (2010)
Population over the age of 30	integer	Health Nutrition and Population Statistics (World Bank 2014)
Crude death rate (annual, per thousand population)	integer	Bollen (2009)
Total forecast energy consumption	Mtoe	Extrapolation from MENR (2014)
Total national energy related CO_2 emissions in 2012 (E_{2012})	$MtCO_2$	INDC and Climate Action Tracker
Total national energy related CO_2 emissions in year x according to current policies (E_{CP})	$MtCO_2$	
Total national energy related CO_2 emissions in year x according to the INDC pathway (E_{INDC})	$MtCO_2$	INDC and Climate Action Tracker
Total national energy related CO_2 emissions in year x according to the 100% renewable pathway (E_{2C})	$MtCO_2$	See section "definition of 100% renewable scenario".
Relationship between the reduction of the emissions of CO_2 and the emissions of air pollutants.	Factor	IIASA (IIASA 2012) and WEO 2012

Estimated emissions of SO_2 and NO_x will be used as a proxy for the emissions of all the major air pollutants under consideration: primary PM, SO_2, NO_x, and NH_3. This simplification recognises that emissions of SO_2 and NO_x are highly influential to the production of secondary particulate matter, and assumes that the emissions of other air pollutants are reduced proportionally to SO_2 and NO_x. A number of studies have applied such simplifications that assume uniform reductions of all these gases for the calculation of local outdoor air pollution, most notably the OECD 2050 Environmental Outlook (OECD 2011). Detailed data for SO_2 and NO_x emissions is not available under all scenarios. Instead, the relationships between CO_2 emission projections and SO_2/NO_x projections were analysed for each individual country to produce an indicative factor that allows for the estimation of air pollutant emissions based upon CO_2 emissions, the data for which is readily available and more easily modelled under various scenarios.

In a first step, the urban atmospheric concentration of PM2.5 is calculated:

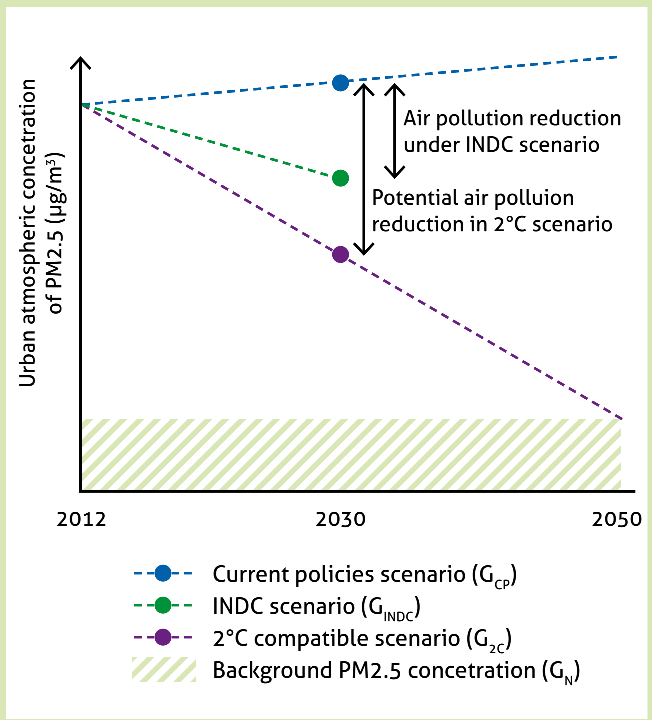
$$\text{Mean exposure to PM2.5 concentrations in year } x = \Delta E\,(G_{2012} - G_N) + G_N$$

ΔE represents the change in emissions of air pollutants that contribute to PM2.5 concentrations, as a ratio of emissions in the calculation year and the base year, 2012. This formula is based on a simplification that assumes a linear decrease of PM2.5 concentrations in line with reduced SO_2 and NO_x emissions. This assumption is consistent with Bollen (2009).

Estimated background levels of PM2.5 that are not attributable to anthropogenic emissions of pollutants (G_N) are taken into consideration. Figure 10 shows how under the 100% renewable compatible scenario (which assumes a reduction to zero CO_2 emissions from energy by 2050), the atmospheric concentration of PM2.5 reduces in linear fashion from its value in 2012 to the value of the background concentration in 2050. Other factors that determine the atmospheric concentration of PM2.5, such as weather conditions and geographical features, are assumed to remain constant.

Figure 10 also shows how the difference in the atmospheric concentration of PM2.5 between the different scenarios can be determined.

FIGURE 10: **Demonstrative calculation methodology for reduced air pollution under different scenarios (not real data)**



In a second step, the reduction of premature mortality can be calculated depending on the change of atmospheric concentration of PM2.5 between scenarios (Bollen 2009; Fang et al. 2013; Public Health England 2014):

Premature deaths from particulate air pollution
=
Attributable factor (AF) × *Crude mortality rate* × *Population*

Attributable factor = $(\beta^G - 1) / \beta^G$

The attributable factor calculates the percentage of deaths which may be attributed to excessive PM2.5 concentrations. In this equation, is the concentration of the pollutant, as demonstrated by Figure 10, given in units of 10 µg/m³. refers to the estimated factor of the log-linear relationship between the concentration of any given pollutant and the resulting mortality rate (concentration-response factor). Krewski et al. (2009) finds a 5.9% risk increase of premature mortality from all causes for every PM2.5 concentration increase of 10 µg/m³. Therefore, the value 1.059 is used for the concentration response factor β, as per Fang et al. (2013) and Bollen (2009). It is common practice when calculating premature deaths from PM2.5 concentrations to consider only the population over 30 years of age (Public Health England 2014).

This study does not use of a low concentration threshold (LCT). The use of an LCT assumes that below a certain level of PM2.5 concentrations, there is no effect on mortality. There is no general consensus on whether the use of an LCT is appropriate or not, due to the lack of empirical evidence that such a threshold does or does not exist. The use of an LCT of 5.8 µg/m³ in this study would reduce the number of calculated deaths by approximately 5,000 – 7,000 per year in all scenarios.

Defining the 100% renewable compatible scenario

The 100% renewable scenario is estimated by using the projections for total energy demand from an extrapolation of MENR (2014), which incorporates polices including EE measures that reduce energy consumption in line with the international 2°C goal, multiplied by a decreasing emissions intensity. We assume a decrease to zero emissions intensity of the energy sector in all countries by 2050. It is further assumed that all countries reach this specific target in 2050 and not before. The emissions intensity of energy is calculated for 2012 based on historical energy demand and emissions data.

Green jobs from renewable energy

Defining the indicator and scope

This section outlines a methodology to determine the impact on employment from the installation of wind, solar and hydro renewable electricity capacity. We use the employment factor approach to quantify direct job creation during two phases of the life cycle, a) manufacturing, construction and installation (MCI) and b) operation and maintenance (O&M). Jobs more broadly related to renewable energy through other phases of the cycle, including research, technological development, consultation, project development, and project evaluation, are not included in the scope of this study. Furthermore, this study only determines the impact on employment of the domestically installed capacity; jobs created through renewables export industry are not included.

This approach is a first approximation of the effect on green jobs. The focus is only on the creation of 'decent green jobs'. For the purpose of this study, we adopt a definition of green jobs provided by ILO(2013):

Green jobs are decent jobs that contribute to preserving and restoring the environment, be they in traditional sectors such as manufacturing and construction, or in new, emerging green sectors such as renewable energy and energy efficiency. Green jobs reduce consumption of energy and raw materials; limit greenhouse gas emissions; minimize waste and pollution; protect and restore ecosystems; and enable enterprises and communities to adapt to climate change.

Accordingly, the methodology does not take into account that jobs may be lost elsewhere through reduced use of fossil fuels or shift of economic activity towards renewables away from other potential activities.

Calculation methodology

According to the International Renewable Energy Agency (IRENA 2014) mayor gaps remain in the generation of data on employment in the renewable energy sector. The main reason for this is that due to the cross-cutting nature of the sector, information is difficult to capture in standard national statistics. To date, only a few countries are collecting relevant data on renewable energy jobs. Relatively detailed data is available only for the United States and several European countries. Better harmonisation of data reporting categories is necessary to improve the quality and comparability of employment data.

In most cases, employment figures are derived from various sources, using heterogeneous methods, assumptions and time frames, which makes comparison of data difficult. One way around this is to use sensitivity analysis to test key data sources and assumptions.

Output indicators

Table 5 presents the output indicators that will be produced from this methodology.

TABLE 5: **Output indicators for reduced air pollution**

Indicator	Unit
Jobs for the construction and installation of hydro, wind and solar electricity installations.	Integer Percentage change
Jobs for the maintenance and operation of hydro, wind and solar electricity installations.	Integer

Method of calculation

To evaluate the impact of an increase in renewable energy and energy efficiency measures on job creation, we follow (IRENA 2014) and apply the employment factor approach. The method is the least resource-intensive method for assessing direct job creation and is based on data for:

- Installed capacities for specific renewable electricity technologies
- Employment factors per unit of installed capacity

Employment factors indicate the number of full-time equivalent (FTE) jobs created per unit of installed capacity. The employment factors are derived in the literature from the following simplified calculation:

$$\textit{Employment factor}_{\mathfrak{R}} = \textit{Jobs created}_{\mathfrak{R}} \,/\, \textit{Installed capacity (MW)}$$

A secondary literature review was carried out to collect employment factors from the most relevant sources on this topic. This allows us to get an idea on data ranges and the uncertainty of results.

For the estimation of job creation in renewable energy deployment, the employment factor approach uses different factors for different phases of the life cycle. We consider two phases: a) manufacturing, construction and installation (MCI) and b) operation and maintenance (O&M). These two phases are considered in most of the available secondary literature on employment generation in the renewable energy sector. Table 6 presents employment factors for the OECD and the US.

To estimate the total number of direct jobs under the current policies, INDC and 100% renewable scenarios, employment factors are multiplied by the calculated renewable energy capacity for each technology type (onshore wind, offshore wind, solar PV, small hydro, and large hydro).

Table 7 presents the required data inputs for the calculation of the co-benefit in any given year.

TABLE 6: **Employment factors for the renewable energy sector from various studies**

Technology	MCI (Jobs per newly installed MW)	O &M (Jobs per MW)	Region	Year of estimation
Wind, onshore	8.6	0.2	OECD countries (Average values)	Various (2006-2011)
	12.1	0.1	US	2010
Wind, offshore	18.1	0.2	OECD countries (Average values)	2010
Solar PV	17.9	0.3	OECD countries (Average values)	Various (2007-2011)
	20.0	0.2	US	2011
Hydro, large	7.5	0.3	OECD countries (Average values)	Various
Hydro, small	20.5	2.4	OECD countries (Average values)	Various
Geothermal	10.7	0.4	OECD countries (Average values)	Various

Source: (Rutovitz & Harris 2012)

TABLE 7: **Data input to calculate employment generation**

Indicator	Unit	Source*
Installed capacity per technology (current policies)	MW	WWF & BNEF (2014)
Installed capacity per technology (INDC scenario)	MW	Turkey's INDC (2015)
Installed capacity per technology (100% renewable scenario)	MW	See defining the 100% renewable scenario, below.
Domestic power demand	MWh	WWF & BNEF (2014)
Capacity factors of renewable tech.	MWh per MW	Derived from WEO 2014
Employment factor per tech. and activity	Jobs/MW	Rutovitz & Harris (2012)

FIGURE 11: **Demonstrative calculation methodology for green jobs created (no real data)**

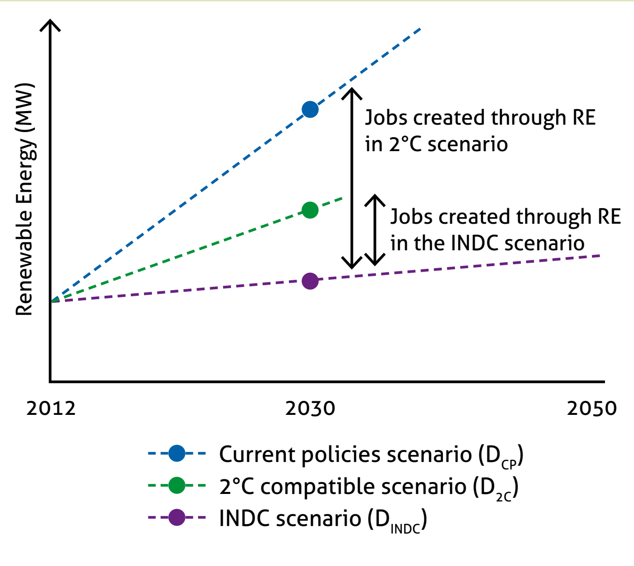


Figure 11 shows how the difference between the number of jobs under each scenario will be determined.

Defining the 100% renewable compatible scenario

The 100% renewable pathway for this indicator is based upon a linear development from today's installed renewable capacity to 100% renewables in the electricity sector by 2050. The total capacity of each renewable energy technology required in 2050 is calculated according to the total forecast electricity demand in 2050, divided by the assumed capacity factors of each renewable energy technology. The proportional split of each technology is based upon the proportional split calculated for 2030 in the Renewables Development Pathway scenario of WWF & BNEF (2014).

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Turkey Climate Network (İklim Ağı) is founded in 2012, in order to jointly raise voices against and promote solutions for climate change. Its founding organizations are Buğday Ekolojik Yaşamı Destekleme Derneği, Doğa Derneği, Doğa Koruma Merkezi, Eurosolar Türkiye, Greenpeace Mediterranean, Heinrich Böll Foundation, Kadıköyü Bilim Kültür Ve Sanat Dostları Derneği (KADOS), TEMA (Turkish Foundation for Combating Soil Erosion, For Reforestation and the Protection of Natural Habitats), WWF Turkey, 350 Ankara,Yeryüzü Derneği, Yeşilist, Yeşil Düşünce Derneği (The Green Thought Association).

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