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Slow but Tangible Progress: The Economic Dividends of Decarbonisation in Cyprus

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Abstract

Instability in global energy supply and fluctuating international oil and gas prices push European countries to reduce fuel import dependency through energy saving measures and faster deployment of renewable energy. Calculating the fuel import bill, as usually done to illustrate the impact of the continent's energy dependency, offers only a partial picture of the challenge. This paper applies an economy-wide assessment for Cyprus, a country which greatly relies on imported fossil fuels but has made some progress towards decarbonisation. We combine energy, economic and trade statistics with technical calculations and find that renewables deployed in the last decade have already today contributed to very substantial net benefits of 469 million Euros at 2023 prices, leading to a benefit-cost ratio ranging between 11 and 19. Input-output modelling shows that economy-wide benefits have led to a cumulative additional value added of the order of 1.4 billion Euros'2023 during the decade 2015-2024, with a 0.5-1% GDP increase per year thanks to renewables investments and avoided fossil fuel imports. The approach presented here minimises the uncertainties and assumptions that are necessary to run more sophisticated economic models and can offer credible insights on the economic dividends of decarbonisation policies in any country, contributing also to improved energy security.

Keywords: decarbonisation; energy policy; energy security; input-output analysis; renewable energy; trade balance

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1. Introduction

Energy policy at national and international level has traditionally been formulated with a view to addressing the 'energy trilemma', i.e. choosing policy mixes that would strike a balance between keeping energy costs affordable for households and firms, ensuring security of supply, and mitigating the energy system's adverse environmental impacts. More recently, the trilemma has been re-formulated to include geopolitical stability (International Energy Agency, 2023). Especially in countries that depend on imports to satisfy most of their energy needs, the importance of energy security has been extensively studied in the international literature due to its crucial role for economic development and social welfare. The interplay between energy costs, security of supply and decarbonisation policies has been particularly relevant for the European Union (EU), whose energy import dependency is still around 60% (Eurostat, 2026a), at times of geopolitical risks that lead to supply shortages and fluctuating oil and gas prices, and with an ambitious green agenda that includes the European Climate Law committing countries to achieve net zero greenhouse gas emissions by 2050 (European Union, 2021).

Research findings about the economic impact of energy dependence vary within the EU depending on national endowments with energy resources, the level of each country's economic development and several other factors. Still, the primary result that emerges from numerous economic analyses deploying diverse methods (econometric, computable general equilibrium and integrated assessment models) is that avoided fossil fuel imports due to decarbonisation policies will generate welfare gains in Europe that are higher than the costs of clean energy investments, even without accounting for the avoided air pollution and climate damages (Borozan, 2025; Dolphin et al., 2024; Schreyer et al., 2025). However, Europe-wide studies, while providing a robust analysis with rich datasets, cannot capture all national particularities that country-specific studies can take into consideration.

At the same time, most of the immediate policy-related analyses focus on the direct impacts only, i.e. the effect of higher fossil fuel prices on the EU's import bill. For example, the European Commission (2026) estimated the EU fossil fuel import bill to reach 550 billion Euros in 2022 and fall to 427 billion Euros in 2024, accounting for about 2.2–3.4% of EU's GDP in the last years. Senior leaders refer to the additional costs of energy imports, such as the reference of the European Commission's President on 13 April 2026 that "since the beginning of the conflict – 44 days ago – our bill for fossil fuel imports has increased by over 22 billion Euros"[1]. SolarPower Europe (2026), a group representing the European solar photovoltaics sector, estimated that without the existing solar electricity, the EU would have paid several billion Euros more in March 2026 for their fuel imports. The think tank Ember (2025) estimated that the EU paid a 930 billion Euro penalty for fossil import reliance during the energy crisis of 2021-2024. However, the import bill provides only a partial picture of the broader impacts as it does

[1] Statement by President von der Leyen on the impact of the situation in the Middle East on the European Union, 13 April 2026.
https://ec.europa.eu/commission/presscorner/detail/en/statement_26_800

not consider how these costs diffuse in the entire economy and to what extent they crowd out investments or expenditures in other economic sectors; moreover, looking at the fuel import bill alone ignores, among other factors, the costs of imports of renewable energy equipment in Europe, which must also be considered in order to examine the net effect on the economy.

To overcome the shortcomings mentioned above, i.e. the partial assessment provided by some policy institutions and the aggregate nature of the EU-wide studies, this paper provides a policy-relevant analysis for the Republic of Cyprus, an island EU Member State that does not possess indigenous fossil fuel resources, depends on imported oil products for most of its power generation but also imports all major renewable energy equipment, and does not have any energy interconnections with other countries. As the country is small and quite different from the EU average in its energy characteristics, a detailed look into its own energy dependence is much more relevant than EU-wide analyses. For this purpose, we rely on actual official national data from the most recent decade to examine the direct impact of renewable energy deployment, which has contributed to a partial independence from fossil fuel imports. We then apply input-output modelling to explore the indirect impacts, i.e. how the costs and benefits of decarbonisation spread in the entire economy, and assess the impacts on economic growth and employment by sector.

Cyprus had the seventh highest per capita greenhouse gas emissions in the EU in 2023 (Eurostat, 2025a) and is the only EU country whose emissions in 2023 were higher than in 1990 (Eurostat, 2025b). Moreover, being a small service-based economy that imports a large part of the goods it consumes, and as an island state that depends on maritime and air transport for the movement of people and commodities, it had the highest consumption-based greenhouse gas footprint in the EU in 2023 with 16.6 t CO_2eq per capita – compared to the EU average of 10.7 t CO_2eq (Eurostat, 2025c). As an EU Member State, the country must reach carbon neutrality by 2050 in line with the European Climate Law, but progress has been quite slow so far. This is mainly due to the slow decarbonisation of power generation and the intensive use of fossil-fuelled private cars.

As far as power generation is concerned, it is dominated by plants using fuel oil and gas oil; most of the power plants are expected to switch to natural gas around 2030, after very long delays. At the same time, penetration of renewable energy sources (RES) in power generation reached almost 24% in 2024, doubling within four years, but is still quite low against an EU average of 47.5% (Eurostat, 2025d); this low performance is expected, however, because Cyprus has limited water resources and hence cannot exploit hydropower and also has limited wind potential. On the other hand, the country has championed the use of solar energy for domestic water heating since many years, so that average exploitation of renewables in the entire energy system (not only for electricity) reached 21.9% in 2024, against an EU average of 25.2%. The fast deployment of solar photovoltaics – both as PV parks and on household rooftops – has not been accompanied by the installation of energy storage facilities yet, so that a substantial fraction of solar and wind electricity generated is currently curtailed; the first major storage units are expected after the end of 2026.

The other major carbon-intensive sector is mobility, with Cyprus being among the EU countries with the highest vehicle ownership and average vehicle age. There has been a sustained promotion of public transport and micromobility in the last years, but these investments take time to materialise and achieve their full potential. Electrification of cars is also moving slowly, similarly to most other Mediterranean and Eastern European EU member states, but with the availability of several affordable car models in the European market in the coming years and the projected further cost reductions it seems to be possible to achieve a share of 8-10% of electric vehicles in the vehicle fleet by 2030, in line with projections of the European Commission and the International Energy Agency (2025a) for EU member states.

Buildings are also a major consumer of energy – mostly electricity – since all buildings before 2008, corresponding to three quarters of the building stock, did not have to comply with any energy performance requirements. Renovation rates are still at low levels and must be accelerated in order to meet the requirements of the revised Energy Efficiency Directive (EU) 2023/1791 and Energy Performance of Buildings Directive (EU) 2024/1275. The buildings sector is highly electrified, with more than half of final energy consumed in the residential and tertiary sector (including a significant portion of space heating) satisfied by heat pumps and other electric appliances and equipment.

The above brief overview of the decarbonisation prospects of Cyprus provides a mixed picture. Progress has been tangible but slow, and carbon neutrality requires much faster deployment of green technologies and enabling policies in the coming years. However, it is easy for the public opinion to dismiss or ignore the progress made so far. Having this as a starting point, our study digs into the environmental and economic benefits from decarbonisation that has been achieved in Cyprus up to now. We focus explicitly on power generation, where progress has been the strongest so far, which allows drawing useful broader conclusions about the low-carbon transition.

Combining energy, economic and trade statistics with technical calculations, we find that already by mid-2025, renewables deployed in Cyprus over the past decade have contributed to the accumulation of net benefits of 469 million Euros at 2023 prices. Benefits will continue to accrue in the coming years and are expected to cumulatively reach almost 3 billion Euros'2023 up to 2035. If the avoided costs from air pollution are accounted for, the net benefits exceed 5 billion Euros'2023, leading to a benefit-cost ratio ranging between 11.4 and 19.2. Input-output analysis shows that economy-wide benefits have led to a cumulative additional value added of the order of 1.4 billion Euros'2023 during the decade 2015-2024. Especially after 2020, when renewables deployment accelerated, we find a 0.5-1% GDP increase per year thanks to renewables and avoided fossil fuel imports, leading also to almost 30,000 new jobs.

The paper continues with the description of our methodology (Section 2), the data used (Section 3), the results (Section 4), and the discussion and concluding comments.

2. Methodology

2.1. Overview

Replacement of fossil fuels by renewable sources in power generation generates direct costs and benefits, which are then propagated in the entire national economy due to the interdependence of economic activities. Within the context of Cyprus, which imports all its fossil fuels as ready products (i.e. it has no refinery), Figure 1 presents the method we used to assess the economy-wide impact of renewable energy deployment.

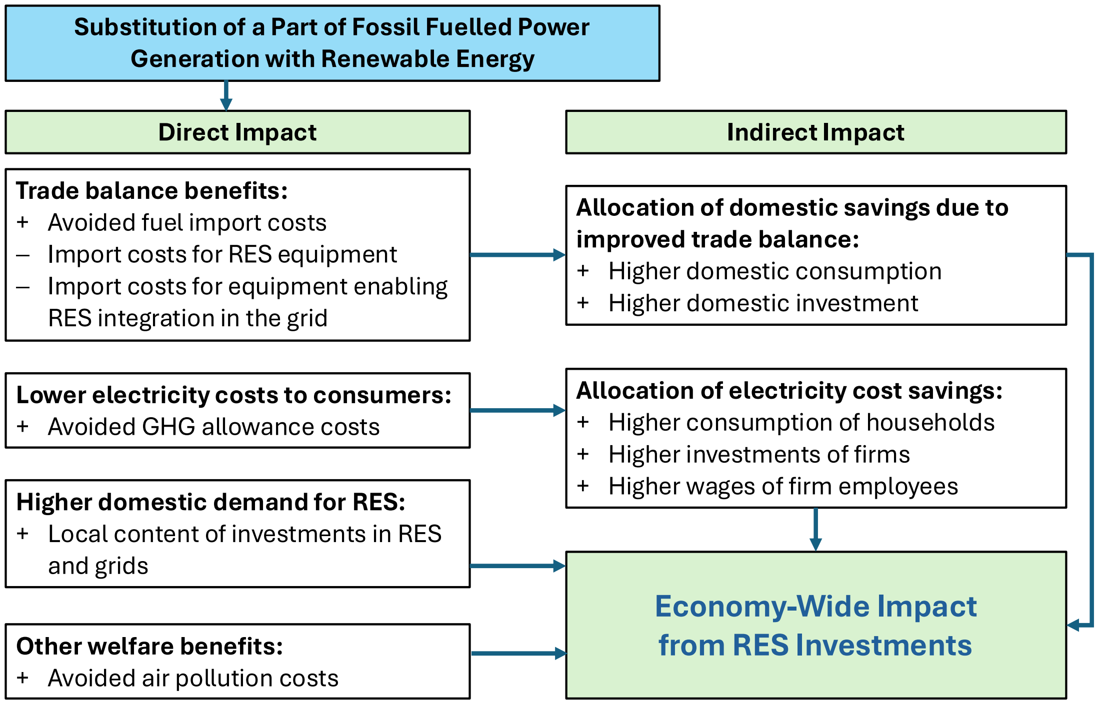


Figure 1: Outline of the methodology to assess the economy-wide impact of renewable energy deployment in Cyprus. "+" denotes a positive economic impact while "–" a negative impact.

2.2. Direct impacts

To assess direct costs and benefits we apply an accounting approach using official past data and the minimum possible assumptions. All electricity generated by renewable sources satisfies a part of demand that would otherwise by met by additional amounts of fossil fuels burnt in the country's power plants. As mentioned above, thermal power generation in Cyprus involves the combustion of fuel oil and gas oil, all quantities of which are imported from abroad as ready fuels, since the country has no oil refinery; hence any fuel imports avoided thanks to RES is a benefit, reducing the operating costs of power plants and improving the country's trade balance. Since the penetration of RES is still modest, as described in the previous section, we consider that the reduction of fossil fuel imports has no negative effect on the economic output of the fuel imports and power generation sectors of the economy. In other words, at the current level of RES penetration there are no stranded assets nor any redundant employees in fossil fuel related sectors.

Additional benefits from green energy use accrue because less combustion of fossil fuels reduces the amount of greenhouse gases (GHG) and air pollutants emitted, thereby lowering costs to society a) by reducing the amount of emission allowances to be purchased for GHG emissions in the EU Emissions Trading System, which are passed through to electricity consumers as additional costs, and b) by improving air quality and alleviating the consequent health impacts thanks to declining air pollutant emissions.

At the same time, RES penetration also has its costs because almost all the equipment (e.g. wind turbines, PV cells and the related accessories) are imported from abroad. Moreover, the integration of RES in the electricity grid requires the installation of specific equipment that would otherwise not be needed; hence, the import costs of this equipment must also be considered on the cost side of the equation.

Since the RES penetration is still modest, we do not assume that it affects the investments in new power plants; therefore, we do not consider benefits from a potential avoidance of the investment costs in new conventional power capacity. Furthermore, we do not account for the future investments in energy storage nor for those to be devoted to the expansion and modernization of the electricity grid because we consider the benefits brought about by the deployment of RES up to now. This means that we also omit the benefits that would arise if no curtailment of RES had happened in case energy storage investments had already been implemented.

Finally, we note that impacts on taxes or other aspects of public finances are not considered in this analysis because they involve redistribution of some financial resources within the country (between the state, consumers and firms), hence they do not bring net impacts to the national economy. Section 3.1 describes the data and assumptions used to assess individual costs and benefits outlined above.

2.3. Indirect impacts

To assess the economy-wide effect stemming from the direct impacts described above, we employ an input-output framework to quantify the macroeconomic impacts of renewable energy investments. The analysis considers four key transmission channels through which renewable energy investments affect the economy: (i) household electricity cost savings, (ii) firm cost reductions, (iii) improvements in the trade balance, (iv) domestic investment in renewable infrastructure. Economy-wide effects are estimated through the corresponding input-output multiplier structure.

Economic effects are propagated through the production system using the standard Leontief input-output model (Miller and Blair, 2008):

$$\Delta X = (I - A)^{-1} \cdot \Delta Y \quad (1)$$

where ΔX is the vector of changes in gross output by sector; I is the identity matrix; A is the matrix of technological coefficients; ΔY is the vector of changes in final demand; $(I - A)^{-1}$ is the Leontief inverse matrix, capturing direct and indirect production linkages.

Type I multipliers are employed, while induced consumption effects are modelled explicitly through a behavioural representation of household income allocation, thereby avoiding double counting within the input-output system. Sectoral Gross Domestic Product (GDP) and employment effects are estimated by applying fixed gross value added (including taxes less subsidies)-to-output and employment-to-output coefficients to total output changes, respectively.

Symmetric input-output tables for Cyprus covering the period 2015-2022 were obtained from the database of the European statistical service (Eurostat, 2026b). Each table was used to estimate the economy-wide effects of renewable energy investments in terms of GDP generation and employment creation. The 2022 table, being the most recent available, is employed to project impacts for the years 2022-2024. The original classification of 65 economic sectors is aggregated into 26 sectors to ensure analytical tractability and consistency with the available data (Table A1 in the Annex).

2.3.1. Household electricity cost savings

Renewable energy deployment reduces wholesale electricity prices, by decreasing reliance on GHG emission allowances, generating household savings (S_H) relative to a counterfactual scenario without renewable investment. A share of these savings is reallocated to consumption (ΔC_H) based on the average propensity to consume:

$$\Delta C_H = (1 - s) \cdot S_H \quad (2)$$

where s denotes the saving rate derived from national accounts. The resulting consumption increase is distributed across sectors according to observed household expenditure patterns and introduced as a final demand shock in the input-output model.

2.3.2. Firm cost savings

Firms also benefit from lower electricity costs, generating operational savings (S_F) that are allocated across investment (ΔI), labour income (ΔW), and retained profits ($\Delta \Pi$) according to observed national accounts income shares:

$$\Delta I = a_I \cdot S_F,\ \Delta W = \varphi \cdot a_w \cdot S_F,\ \Delta \Pi = a_\pi \cdot S_F \quad (3)$$

where a_I, a_w and a_π are the observed shares of gross fixed capital formation (GFCF), employee compensation, and gross operating surplus in sectoral value added (Eurostat, 2026c; 2026d); $\varphi \in [0,1]$ is a wage pass-through parameter capturing the partial transmission of cost savings to labour income, calibrated in the range 0.10-0.30 consistent with empirical evidence on rent-sharing (Katz et al., 1989; Blanchflower et al., 1996; Card et al., 2018). The constraint $a_I + \varphi \cdot a_w + a_\pi = 1$ ensures internal consistency with national accounting identities.

Only the components that translate into additional demand are incorporated into the input-output framework. The investment component is introduced as an exogenous increase in GFCF, distributed across sectors using the observed investment structure. The labour income component augments household income and generates additional consumption (ΔC_W):

$$\Delta C_W = (1 - s) \cdot \Delta W \quad (4)$$

The profit retention component ($\Delta \Pi$) is not explicitly modelled. While retained earnings can in principle stimulate secondary demand through dividends, share buybacks, or reinvestment (Fazzari et al., 1988; Opler et al., 1999), their aggregate effect depends on heterogeneous household behaviour across income classes (Piketty and Saez, 2003; Dynan et al., 2004) - a dimension not captured by standard input-output models, which treat all households as a single group with uniform spending behaviour (Miller and Blair, 2009).

2.3.3. Trade balance benefit

Renewable energy deployment reduces dependence on imported fossil fuels, generating foreign exchange savings (S_T) retained within the domestic economy. These resources are reallocated to domestic consumption (ΔC_T) and investment (ΔI_T) according to the observed final demand composition:

$$\Delta C_T = \alpha_C \cdot S_T,\ \Delta I_T = \alpha_I \cdot S_T \quad (5)$$

where α_C and α_I are the consumption and investment shares in total final demand, calibrated from national accounts. Both components are injected into the input-output model using the corresponding sectoral structures. This approach captures the direct demand stimulus from import substitution, abstracting from general equilibrium feedback effects such as exchange rate appreciation or shifts in export competitiveness (Armington, 1969; Corden and Neary, 1982).

2.3.4. Direct domestic investment in renewable energy infrastructure

Renewable energy deployment generates direct economic activity through domestic investment in infrastructure, particularly in photovoltaic installations and the associated grid connection works. These investments constitute an exogenous increase in final demand within the input-output framework, reflecting expenditures that are realised locally in Cyprus. Two investment components are distinguished: (i) expenditures associated with photovoltaic installations, and (ii) expenditures related to the connection of renewable energy systems to the electricity grid. The sectoral allocation of investment expenditure is based on the technology-specific cost structure proposed by Taliotis et al. (2020).

3. Data

3.1. Data for the components of direct costs and benefits

This section presents the data used and assumptions made for the calculation of all components of the direct economic impact outlined in the methodological Section 2.1. A summary of all the assumptions and input values is provided in Table 1. All costs and benefits of past years have been expressed at constant Euros of the year 2023, using GDP deflators stemming from the official national accounts published by the national Statistical Service (Cystat) in spring 2025.

Table 1: Assumptions and input data for the calculations of this paper.

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Comments
Electricity generated from RES (GWh)	321.87	382.96	419.70	445.94	473.50	501.61	583.87	759.73	893.62	1115.87	1388.13	Source: Eurostat SHARES database (Eurostat, 2026e).
CO2 emissions saved (kt)	241.41	287.22	314.78	334.45	355.13	376.21	437.90	569.80	670.21	836.90	1041.10	Weighted average fuel oil & gas oil emission factor: 0.75 t CO2eq / MWh
ETS allowance price (€/tCO2e)	5.9	7.6	5.3	5.8	14.9	24.7	24.6	52.5	80.4	83.7	65.0	Source: German Emissions Trading Authority. Average auction prices for EUA (excluding aviation allowances) from the primary (auction-level) market: https://www.dehst.de/EN/Home/home_node.html
Emission costs saved (M€)	1.4	2.2	1.7	1.9	5.3	9.3	10.8	29.9	53.9	70.0	67.7	Allocation of emission cost savings between households and firms is based on the share of each category in final electricity consumption per year
Savings for households	*0.5*	*0.8*	*0.6*	*0.7*	*1.9*	*3.5*	*4.4*	*11.7*	*19.7*	*24.2*	*23.4*	
Savings for businesses	*0.9*	*1.4*	*1.1*	*1.2*	*3.4*	*5.8*	*6.3*	*18.2*	*34.2*	*45.8*	*44.3*	
Fuel oil saved (kilotonnes)	70.0	83.3	91.2	96.9	102.9	109.0	126.9	165.2	194.3	242.6	301.8	Assuming a thermal efficiency of power plants of the Electricity Authority of Cyprus (EAC) of 40% and heating value of 11.5 kWh/kg
Fuel oil import price (€/tonne)	501	328	245	332	418	459	410	546	929	874	792	Based on EAC data: https://www.eac.com.cy/EN/RegulatedActivities/Supply/tariffs/Pages/Fuel-Cost.aspx & https://www.eac.com.cy/EN/RegulatedActivities/Supply/tariffs/Pages/anaprosarmogitimiskavsimou.aspx.
Fuel import costs saved (M€)	35.1	27.3	22.3	32.1	43.0	50.0	52.1	90.2	180.4	212.0	239.1	
Emission factors of fossil fuel power generation in Cyprus (t/GWh of electricity generated)												
Nitrogen oxides (NOx)	0.531	0.531	0.531	0.531	0.531	0.531	0.531	0.329	0.334	0.340	0.349	For 2020-2023, emission factors are based on actual operational data; for 2024, based on NECP projections; assumption that pre-2020 the same EFs with 2020 apply.
Sulphur dioxide (SO2)	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.727	0.700	0.755	0.797	
Particulate matter (PM)	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.056	0.054	0.064	0.064	
NOx emissions avoided (t)	170.8	203.2	222.7	236.6	251.2	266.1	309.8	249.9	298.5	379.0	484.1	
SO2 emissions avoided (t)	240.6	286.2	313.7	333.3	353.9	374.9	436.4	552.2	625.2	842.4	1106.2	
PM emissions avoided (t)	17.1	20.3	22.2	23.6	25.1	26.6	30.9	42.5	48.0	70.9	88.4	
Air pollution costs avoided (M€'2023)	46.2	54.9	60.2	64.0	67.9	71.9	83.7	104.4	118.3	159.3	209.0	
Costs of PV imports (M€)		4.9	5.4	7.1	6.2	20.1	18.3	23.0	51.3	42.0	25.8	Data in current prices. See main text for source of data.
Costs of equipment for connecting RES to the distribution system (M€)		5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	
To net-metering / net-billing customers		*1.3*	*1.3*	*1.3*	*1.3*	*1.3*	*1.3*	*1.3*	*1.3*	*1.3*	*1.3*	
Connection of RES parks to medium/low voltage grid		*4.1*	*4.1*	*4.1*	*4.1*	*4.1*	*4.1*	*4.1*	*4.1*	*4.1*	*4.1*	
Costs of equipment for connecting RES to the transmission system (M€)		0.0	0.0	4.0	0.7	0.8	0.5	1.2	0.9	0.6	2.8	

Auxiliary data

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	
Deflators to 2019 (Cystat)		0.972	0.967	0.977	0.987	1.000	0.988	1.018	1.086	1.128	1.168	Source: National Accounts, Cyprus Statistical Service, 23/04/2025
Deflators to 2023 (Cystat)		0.862	0.857	0.866	0.875	0.887	0.876	0.903	0.963	1.000	1.035	

Assumed marginal damage costs per tonne of NOx, PM and SO2: 9,006, 140,000 and 17,122 Euros'2016. Source: CASES (Cost Assessment for Sustainable Energy systems) – Final Conference Proceedings and External Costs Database. 2008. http://www.feem-project.net/cases/downloads_deliverables.php

Euros'2023/t
NO_x
PM2.5
SO_2

Deflator 2016-2020: 1.13

Deflator 2016-2023: 1.3

3.1.1. Avoided fuel import costs

Total annual power generation from all renewable sources was obtained from Eurostat's SHARES (Short Assessment of Renewable Energy Sources) database (Eurostat, 2026e). Each kilowatt-hour of electricity generated from RES every year is considered to replace one kilowatt-hour that would be generated from a thermal power plant. Based on the annual reports of the Electricity Authority of Cyprus (EAC), the weighted average thermal efficiency of the power plants operating during the last decade in Cyprus was around 40%. In this way one can calculate the amount of fuel saved thanks to the operation of RES.

To calculate the cost savings, we combined the amount of fuel saved per year with the annual average fuel import cost as reported by EAC for the period 2013-2024[2]. These cost savings can be considered as directly benefiting the Cypriot economy as they reduce the value of total imports and thereby improve the country's trade balance.

3.1.2. Reduction in greenhouse gas emissions and their costs

In line with the emission factors suggested by the IPCC, for the fuel mix of thermal power generation in Cyprus (consisting of fuel oil and gas oil) and for the average thermal efficiency of the specific power plants, we assume a weighted average GHG emission factor of 0.75 tonnes of CO_2-equivalent per Megawatt-hour of electricity generated. Hence, each kilowatt-hour of electricity generated from RES is considered to save 0.75 kilograms CO_2eq.

Emission savings were converted to cost savings by using the average annual price of emission allowances covered by the EU Emissions Trading System (ETS). These were obtained by the German Emissions Trading Authority (DEHSt)[3].

3.1.3. Avoided health damages

We consider that three air pollutants from combustion in power generation are responsible for adverse health impacts: nitrogen oxides (NOx), sulphur dioxide (SO_2) and particulate matter with an effective radius of up to 2.5 microns ($PM_{2.5}$). In line with the emission factors for these air pollutants reported by EAC and from information in standard emission factor handbooks (European Environment Agency, 2023), and based on the average operation of EAC's power plants in recent years, we arrived at emission factors of 0.53, 0.75 and 0.053 grams of NOx, SO_2 and $PM_{2.5}$ respectively per kilowatt-

[2] See https://www.eac.com.cy/EN/RegulatedActivities/Supply/tariffs/Pages/Fuel-Cost.aspx & https://www.eac.com.cy/EN/RegulatedActivities/Supply/tariffs/Pages/anaprosarmogitimiskavsimou.aspx - last accessed on 30 March 2026.

[3] The data we used refer to average auction prices for EUA (EU emission allowances excluding aviation allowances) from the primary (auction-level) market (https://www.dehst.de/EN/Home/home_node.html - last accessed on 23 August 2025). Data from the secondary auction market differ only very slightly.

hour of electricity generated. Therefore, each kilowatt-hour of electricity from RES saves the equivalent amounts of air pollutants.

The health effects of the main air pollutants are well documented in the literature, and there is a growing number of assessments about the actual impacts to human health due to exposure of people to high levels of ambient concentrations of certain air pollutants. The impacts are usually expressed in premature deaths and in years of life lost. Emission reductions due to less operation of thermal power plants lead to an improvement in air quality, and thus to a decrease in adverse health impacts. Such health benefits can be expressed in monetary terms by using assessments of the external cost of each pollutant; this is the sum of the economic damage caused per tonne of pollutant emitted to the atmosphere on human health, crops, materials and biodiversity – although damages related to human health dominate. For assessing the cost of NOx, PM and SO_2 emissions, we used calculations of the European CASES project (FEEM, 2008) for emissions from power plants, as was also done in the National Energy and Climate Plan of Cyprus. All values were converted to constant Euros'2023 per tonne of pollutant. Benefits are strongest from the reduction in PM emissions because these have the most adverse health impacts and hence the highest damage costs per tonne. Based on the above-mentioned study, the assumed marginal damage costs per tonne of NOx, PM and SO2 were 11,708, 182,000 and 22,259 Euros'2023 respectively.

3.1.4. Import costs for renewable energy equipment

RES equipment, primarily wind turbines, PV panels and their accessories, are imported in Cyprus from abroad. Therefore, to formulate a balanced assessment about the effect of the green transition on the trade balance, it is necessary to identify the value of imports of these items.

We obtained such information from detailed official trade statistics. These were available in Cystat's online database from year 2021 onwards[4] and in Cystat external trade publications for earlier years. In post-2021 statistics, these were the import data for commodity codes 85017100, 85017200, 85018000, 85414200, 85414300. For statistics up to 2021, we used the data for the available commodity code 85414090 (photosensitive semiconductor devices), which is more aggregate but seems to account almost exclusively for PV panels. We used data for the decade 2015-2024, hence we focused on PV imports because essentially all wind farms had been installed before 2015 (Eurostat, 2026e). Before 2013 there was also significant exporting activity of PV panels from Cyprus to other countries due to domestic PV production.

As shown in Table 1, the value of PV imports was around 5 million Euros per year in 2015-2016, reached a peak of 51 million Euros in 2022 and declined in 2023-2024 to 42 and 26 million Euros respectively, most probably reflecting the decrease in PV costs over the years, in combination with fluctuating international transport costs and declining demand from the PV park investors post-2022 as the PV park installation programme under the transitional market scheme in Cyprus had been completed. It is important to

[4] See https://cystatdb.cystat.gov.cy/pxweb/en/8.CYSTAT-DB/ - last accessed on 20 April 2026.

keep in mind that these costs are related to new PV panels installed, which means that these imports offer benefits throughout the lifetime of the panels.

3.1.5. Import costs for equipment enabling the integration of RES

The integration of renewables in the electricity grid requires specialised investments, both in the transmission system (i.e. at high voltage) and at the distribution system (at low and medium voltage). A large part of these investments involves the installation of equipment (substations, transformers, inverters etc.) which is imported from abroad. These import costs must be accounted for when assessing the net effect of RES deployment on the economy, whereas labour and overhead costs for the firms installing this equipment are not considered as costs to the national economy because they involve employment of local personnel, company profits, etc. To assess the import costs of such equipment, we obtained information from experts on the transmission and distribution system of Cyprus the Cypriot electricity grid.

As regards the *distribution system*, two cost items were considered:

- Costs for equipment that enables self-consumption of RES by citizens and firms who benefit from net-metering and net-billing schemes. This cost was estimated at 250 Euros per installation, out of which the equipment cost amounts to around 150 Euros. By the end of 2024, around 83,000 net-metering and 1700 net-billing customers were connected – essentially all of them with PV panels. At 150 Euros each, the equipment cost reached 12.7 million Euros for all systems that had been installed up to 2024.
- Costs for equipment that is installed in RES parks connected at medium and low voltage. By the end of 2024, 159 parks had been connected at medium voltage (3 wind farms, 5 biomass installations and the rest were PV parks) and 1861 PV parks had been connected at low voltage. Considering the very different equipment costs for the connection of RES parks at medium and low voltage (200,000 Euros and 5000 Euros respectively), the total equipment cost is estimated at 41 million Euros[5].

As regards the *transmission system*, investments planned over the decade 2015-2024 were of the same order with those of the distribution system, but the ones which have been actually implemented and were specifically intended for enabling the connection of RES with the grid is estimated by experts at around 12 million Euros for the decade 2015-2024. These investments will need to grow in the coming years to accommodate more RES capacity, but it is reasonable to assume that these have been sufficient for integrating the amounts of RES that have already been installed in the national energy system.

[5] This is in line with an alternative calculation provided by experts, using the apportionment method: total investments to modernise, upgrade and expand the electricity distribution system of Cyprus reached 400 million Euros over the decade 2015-2024, and an expert estimate assumes 10% of these investments were dedicated to the installation of equipment connecting RES projects to the grid – which leads to a RES-relevant equipment cost of 40 million Euros.

As also mentioned in the previous section, these costs are related to infrastructure with a long lifetime, which means that these equipment imports offer benefits for many years in the future.

3.2. Data for economy-wide impacts

To assess the local content of RES expansion, as explained in the methodology, one needs to obtain data on two investment components: those associated with photovoltaic installations as such, and those related to investments in enabling infrastructure, i.e. to connect renewables to the electricity grid.

For the local content of PV installations, we considered that this equals the amount of capital expenditure for PV panels each year of the decade 2015-2024 minus the PV import costs per year as available from the trade statistics mentioned above. Annual capital expenditures were calculated by multiplying the amount of newly installed capacity per year (in MW) with the investment costs per year (in Euros'2023 per MW). The capacity installed per year is available from the annual reports of the Transmission System Operator of Cyprus (2026). The investment cost of PV panels in the Cypriot market conditions was derived from a combination of official statistics of the International Renewable Energy Agency (2025b) with the investment cost estimates used in the first and the second National Energy and Climate Plans of Cyprus (Republic of Cyprus, 2020; 2024), which reflect actual Cypriot market conditions per year. We used an estimate of the average of rooftop PV and utility-scale PV installation costs, since the amount of installed capacity has been similar in the two categories.

As for the local content of grid investments, we relied on expert assessments from senior experts from the Transmission and Distribution System Operators of Cyprus. According to these, the labour and overhead costs (i.e. the local content) for installation of self-consumption systems (net-metering and net-billing) in the distribution system amount to 67% of the corresponding equipment costs, whereas for utility-scale PV parks this cost is about 40% of the equipment costs. For investments in the transmission system, which are more capital-intensive, the labour and overhead costs are estimated at 10% of the corresponding import costs of equipment.

Table 2 presents the results of these calculations and assumptions, which were used as input to the input-output model. As a next step, this local content was allocated to economic sectors based on the assumptions reported by Taliotis et al. (2020).

Table 2: Parameters to calculate the local content of RES investments in Cyprus in the decade 2015-2024. More information about data sources is provided in the text.

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total 2015-2024	Comments
PV installation cost (€'2023/kW)	2192	2075	1957	1839	1722	1604	1495	1405	1242	1125		Source: IRENA Renewable power generation costs in 2024 (2025) & assumptions used in the NECPs of Cyprus of 2020 & 2024
Installed PV capacity (MW)	76.5	85.7	112.1	122.7	149.5	229	293	431	623	797		Source: Annual reports of the Transmission system Operator of Cyprus - https://tsoc.org.cy/organization/annual-reports/
New installations / year (MW)	15.5	9.2	26.4	10.6	26.8	79.5	64	138	192	174	736	Additional capacity per year, based on the data of the previous row
Cost of new PV installations (M€'2023)	34.0	19.1	51.7	19.5	46.1	127.5	95.7	193.9	238.5	195.7	1021.7	New installed capacity (previous row) multiplied by installation cost per year (first row)
Costs of new PV imports (M€'2023)	5.7	6.3	8.2	7.1	22.7	20.9	25.5	53.2	42.0	24.9	216.6	Data from Table 1, converted to Euros at 2023 prices
Local content (labour + equipment) of PV installations (M€'2023)	**28.3**	**12.8**	**43.5**	**12.4**	**23.5**	**106.6**	**70.2**	**140.6**	**196.5**	**170.8**	**805.1**	This is equal to the difference between the previous two rows: total cost of PV installations minus the cost of their imports
Local content (labour + equipment) for connecting RES to the distribution system (M€'2023)	2.9	2.9	2.9	2.8	2.8	2.8	2.8	2.6	2.5	2.4	27.4	Based on total equipment costs for connecting RES to the distribution and transmission system (see Table 1) and private communication with current and former senior staff of electricity authorities about the costs of labour and overheads of Cyprus-based firms performing threse installations
Local content (labour + equipment) for connecting RES to the transmission system (M€'2023)	0.0	0.0	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.3	1.3	
Local content (labour + equipment) for connecting RES to the grid (M€'2023)	**2.9**	**2.9**	**3.3**	**2.9**	**2.9**	**2.9**	**2.9**	**2.7**	**2.6**	**2.7**	**28.7**	Sum of the local content of investments in the distribution + transmission systems

4. Results

4.1. Direct costs and benefits

Table 3 shows the calculated costs and benefits according to the methodology outlined in the previous section. Instead of accounting for the installed RES capacity and assuming the degree of its utilisation per year, we consider the actually generated electricity in all years of the decade 2015-2024, during which essentially all RES capacity installed comprised solar PVs (in commercial parks as well as on rooftops). We remove the effect of RES installed prior to 2015 by considering only the additional electricity generated from 2015 onwards in comparison to that generated in 2014. This allows us to focus only on the electricity generated by new PV panels from 2015 onwards, for which we also have their import costs (from official trade statistics as explained in section 3.1.5). Since we focus on the actual power generation, we don’t need to make assumptions about the level of curtailment per year and per PV type; we take into consideration the curtailment actually implemented to PVs in the entire national energy system each year up to 2024.

To properly assess the benefits of PV installations, we must consider their entire lifetime because the import costs of PV panels and the infrastructure that were incurred during 2015-2024 to connect these panels to the grid have a long lifetime that exceed the time horizon of that decade. As PV panels have a lifetime of 15 to 20 years and we are here exploring the effect of panels installed between 2015 and 2024, we extend the calculation of cost savings up to the year 2035. We thereby assume that all PVs installed up to the year 2024 will yield economic benefits equal to those of year 2024 for another eleven years (i.e. 2025-2035); this is a quite conservative assumption, since the PV panels installed between 2021-2024 will be less than fifteen years old in 2035, but allows the calculations to be on the safe side since we do not account a) for import costs of PV-related equipment (e.g. inverters) that may need to be replaced during the lifetime of the PV panels and b) for disassembly costs of PVs, which may partly be a cost to society (e.g. waste to be managed properly).

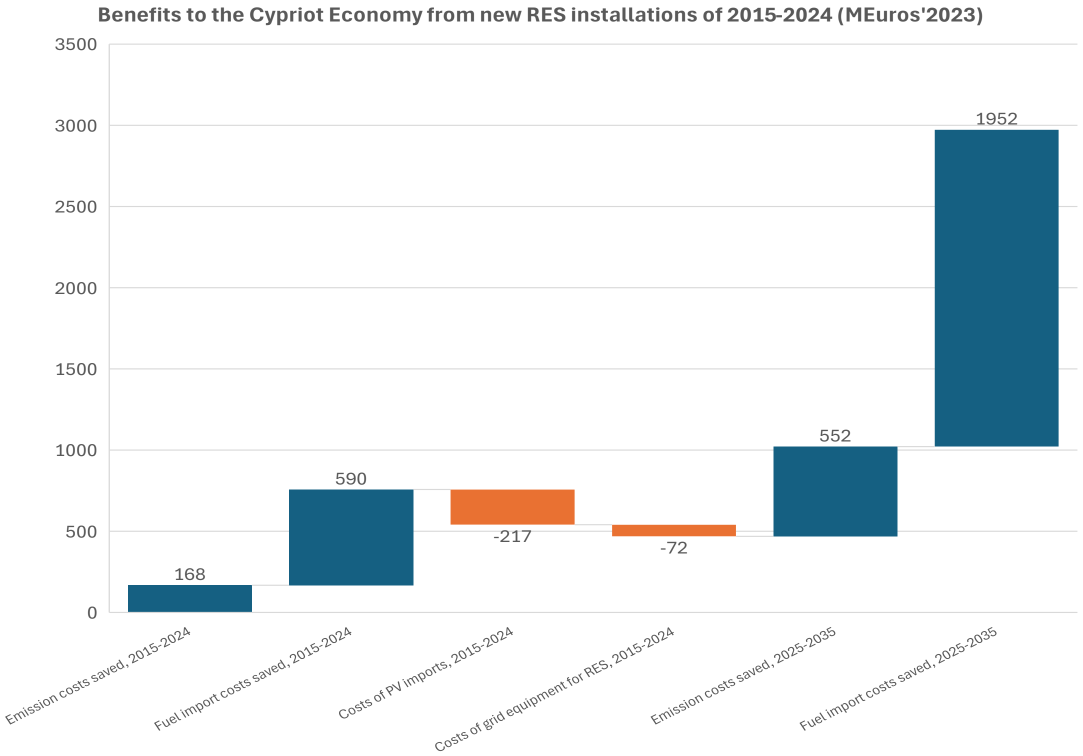
To calculate cost savings post-2024, we assume that fuel prices and carbon allowance prices will remain up to 2035 at the levels of 2024, and that curtailment will also remain on average as large as in 2024. There are reasons to regard some of these assumptions as under- or over-estimations, but they offer a reasonable accounting framework.

This means that Table 3 reports the costs and the benefits only from the operation of those RES installed during the decade 2015-2024 up to the end of their lifetime. The corresponding costs and benefits of RES investments before 2015 and those deployed from 2025 onwards are not accounted for in Table 3. Figure 2 summarises the same results, accounting only for monetary costs and benefits (top graph) and considering also air quality related benefits (bottom graph).

<u>Table 3</u>: Costs and benefits from the deployment of the renewable electricity investments implemented in Cyprus during the decade 2015-2024. The table shows only the impact that is additional to that caused by renewables installed prior to 2015.

Additional effects from RES deployment in the decade 2015-2024 (change in comparison to the year 2014)														
	2015	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Total for 2015-2024**	**Projected for 2025-2035**	**Total for the period 2015-2035**	**Benefit-Cost Ratio**
Electricity generated from RES (GWh)	61.1	97.8	124.1	151.6	179.7	262.0	437.9	571.7	794.0	1066.3	**3746**	**11729**	**15475**	
CO2 emissions saved (kt)	45.8	73.4	93.0	113.7	134.8	196.5	328.4	428.8	595.5	799.7	**2810**	**8797**	**11606**	
Emission costs saved (M€'2023)	0.4	0.5	0.6	1.9	3.7	5.5	19.1	35.8	49.8	50.2	**168**	**552**	**720**	
Cost savings for households (M€'2023)	*0.1*	*0.2*	*0.2*	*0.7*	*1.4*	*2.3*	*7.5*	*13.1*	*17.2*	*17.3*	***60***	***191***		
Cost savings for businesses (M€'2023)	*0.3*	*0.3*	*0.4*	*1.2*	*2.3*	*3.2*	*11.6*	*22.7*	*32.6*	*32.9*	***108***	***361***		
Fuel oil saved (kilotonnes)	13.3	21.3	27.0	33.0	39.1	57.0	95.2	124.3	172.6	231.8	**814**	**2550**	**3364**	
Fuel import costs saved (M€'2023)	5.1	6.1	10.3	15.7	20.2	26.7	57.6	119.8	150.9	177.4	**590**	**1952**	**2541**	
NOx emissions avoided (t)	32.4	51.9	65.8	80.4	95.4	139.0	144.0	191.0	269.7	371.9	**1441**	**4090**	**5532**	
SO2 emissions avoided (t)	45.7	73.1	92.7	113.3	134.3	195.8	318.3	400.0	599.4	849.7	**2822**	**9347**	**12169**	
PM emissions avoided (t)	3.2	5.2	6.6	8.0	9.5	13.9	24.5	30.7	50.5	67.9	**220**	**747**	**967**	
Air pollution costs avoided (M€'2023)	10.2	16.4	20.5	24.9	29.1	42.9	66.6	78.6	113.4	155.0	**558**	**1705**	**2263**	
Costs of PV imports (M€'2023)	5.7	6.3	8.2	7.1	22.7	20.9	25.5	53.2	42.0	24.9	**217**		**217**	
Costs of equipment for connecting RES to the distribution system (M€'2023)	6.2	6.3	6.2	6.1	6.1	6.1	6.0	5.6	5.4	5.2	**59**			
To net-metering / net-billing customers	*1.5*	*1.5*	*1.5*	*1.5*	*1.4*	*1.4*	*1.4*	*1.3*	*1.3*	*1.2*	**14**		**14**	
Connection of RES parks to medium/low voltage grid	*4.8*	*4.8*	*4.7*	*4.7*	*4.6*	*4.7*	*4.6*	*4.3*	*4.1*	*4.0*	**45**		**45**	
Costs of equipment for connecting RES to the transmission system (M€'2023)	0.0	0.0	4.6	0.8	0.9	0.6	1.3	0.9	0.6	2.7	**13**			
Total costs (M€'2023)											**288**	**0**	**288**	
Monetary benefits (M€'2023)											**757**	**2504**	**3261**	**11.3**
Total benefits incl. avoided pollution costs (M€'2023)											**1315**	**4209**	**5524**	**19.2**

Monetary net benefits per GWh of solar PV generated (M€):	**0.192**	
Total net benefits per GWh of solar PV generated (M€):	**0.338**	
Monetary net benefits per MW of solar PV installed (M€):	**5.23**	Assuming a lifetime of 17 years and 1600 kWh/kW PV generation per year (actual figure is higher, especially for commercial PV parks, but this is a conservative assumption to account for gradual degradation of PVs during their lifetime and some degree of curtailment).
Total net benefits per MW of solar PV installed (M€):	**9.20**	



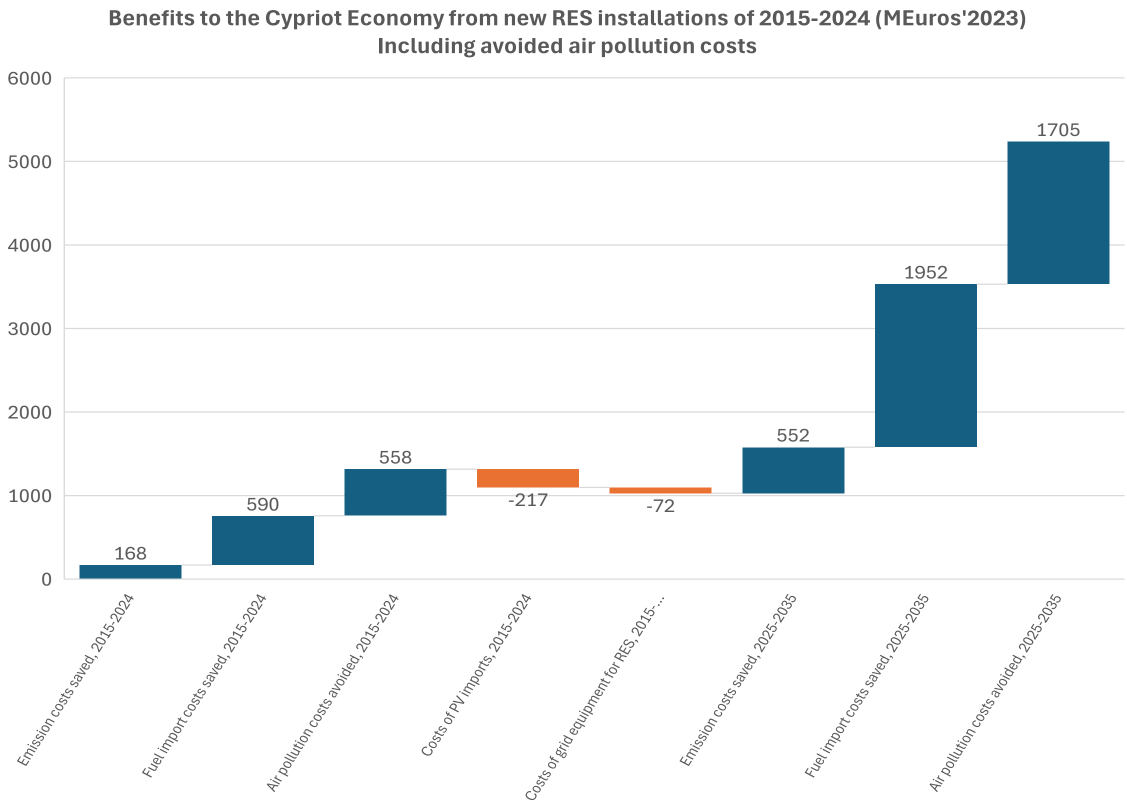


Figure 2: Costs and benefits from RES deployment, considering monetary items only (upper graph) and accounting for air pollution costs as well (bottom graph).

Our assessment shows that the RES deployment of the decade 2015-2024, thanks to the operation of these installations until 2035, is expected to yield net direct benefits to the Cypriot economy of almost 3 billion Euros at constant prices of year 2023. We estimate that the benefits already realised up to now (in 2015-2024) accrued to 757 MEuros'2023 (590 million of fuel import cost savings and 168 million of emission cost savings), versus 217 million of PV import costs and 72 million of imports for equipment that enabled the integration of PVs in the grid. This means that already by mid-2025 the RES deployed in Cyprus in the past decade had yielded net benefits of 469 million Euros'2023.

Benefits will continue to accrue in the coming years and, as mentioned above, are expected to cumulatively reach almost 3 billion Euros'2023 up to 2035. If the avoided costs from air pollution are accounted for, the net direct benefits exceed 5 billion Euros'2023. This leads to a benefit-cost ratio ranging between 11.4 and 19.2 – a clear indication of the very substantial socioeconomic benefits offered by the deployment of renewable electricity in a country depending on imported high-carbon fuels for its power generation.

The bottom part of Table 3 provides also an assessment of the net benefits per unit of electricity generated and per unit of PV capacity installed. It turns out that each Gigawatt-hour of electricity produced by RES yields economic benefits between 192 and 338 thousand Euros'2023; and considering the lifetime electricity generation of PV panels (under the assumptions reported in Table 1), each Megawatt of PV capacity installed in Cyprus during the last decade is expected to yield net economic benefits of 5.2-9.2 million Euros'2023 in total throughout its lifetime.

4.2. Economy-wide impact

We now turn to the assessment of how these direct benefits have been diffused in the economy, by applying the input-output methodology described in Section 2.3. We ran the IO model for each year of the decade 2015-2024, which allowed to look into the economy-wide effect of decarbonisation, i.e. the combined effect of investments in renewables and reduction in fossil fuel imports for power generation.

We distinguish between the individual indirect impacts shown on the right part of Figure 1, i.e. (i) higher domestic private consumption due to improved trade balance, (ii) higher domestic investments due to improved trade balance, (iii) higher household expenditures due to lower electricity costs, (iv) higher investments of firms due to lower electricity costs, and (v) higher employee wages due to lower electricity costs of firms. Finally, the economic impact of the local content of RES investments is also included.

Table 4 shows the summary impact on GDP and employment for each year of the decade 2015-2024. Detailed sectoral results for each one of the six impacts on output, GDP and employment can be provided by the authors upon request. We find that decarbonisation, i.e. the combination of investments in renewables with the reduction in the use of fossil fuels for power generation, increased the GDP of Cyprus by 0.5% on average during the last decade. The effect has been stronger since 2020, when RES deployment accelerated: the positive impact on growth ranged between 0.5% and 1.1% of GDP per year, leading also to a rise in employment between 0.6% and 1.4% as the shift benefited more labour-intensive sectors. About half of the positive effects are due to RES investments as such, which increased economic activity of Cypriot companies. The rest of the positive impact is primarily due to the improved trade balance that freed up resources for domestic consumption and investments in the economy.

Table 5 shows the aggregate impact by economic sector. Decarbonisation has primarily provided stimulus to sectors related to RES installation (manufacturing of machinery, equipment and metal products) as well as to some sectors which already drive the Cypriot economy (construction, real estate, food manufacturing and trade) and have probably enjoyed higher demand thanks to the redirection of expenditures for fossil fuel imports to consumption and investments in the national economy.

Table 4: Impact of RES deployment on GDP and economy-wide employment in Cyprus during the decade 2015-2024.

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2015-2024
Impact on GDP (million Euros)												
Impact of improved trade balance on:	Domestic consumption	4.1	4.8	7.6	11.7	15.0	19.9	42.8	86.6	108.3	117.5	418.2
	Domestic investments	0.6	1.1	2.0	2.9	3.6	5.3	11.8	24.1	32.0	32.8	116.2
Impact of electricity cost savings on:	Household expenditure	0.1	0.2	0.2	0.6	1.2	1.8	5.9	11.4	14.9	13.8	50.2
	Firm investments	0.0	0.1	0.1	0.3	0.5	0.7	2.6	5.0	7.6	6.6	23.4
	Employee wages	0.0	0.0	0.0	0.1	0.2	0.3	0.9	2.0	2.9	2.7	9.2
	Local content of RES investments	28.2	14.1	41.1	13.8	19.4	98.7	65.5	128.7	178.7	155.7	744.0
	Total Impact	33.1	20.2	51.1	29.4	39.9	126.7	129.5	257.6	344.5	329.1	1361.2
Total impact at constant prices (MEuros'2023)		39.1	24.0	59.9	34.2	45.7	147.0	145.8	272.1	344.5	319.1	1431.4
Actual GDP at constant prices (MEuros'2023)		21149	22540	23836	25331	26819	25956	28914	31306	32439	33718	272007
Impact of RES on the economy as % of GDP		**0.2%**	**0.1%**	**0.3%**	**0.1%**	**0.2%**	**0.6%**	**0.5%**	**0.9%**	**1.1%**	**0.9%**	**0.5%**
Impact on employment (no. of jobs)												
Impact of improved trade balance on:	Domestic consumption	107.5	132.9	196.9	294.7	365.8	514.4	976.7	1815.1	2328.3	2568.4	9300.8
	Domestic investments	11.6	22.1	34.2	44.9	52.8	81.4	177.8	293.8	403.4	421.7	1543.8
Impact of electricity cost savings on:	Household expenditure	3.6	4.2	5.3	15.6	29.7	47.6	135.9	238.2	320.9	302.0	1102.9
	Firm investments	0.6	1.2	1.5	4.0	6.9	11.2	38.6	60.5	96.3	84.8	305.6
	Employee wages	0.6	0.7	0.9	2.7	5.0	6.9	20.5	38.8	58.5	54.8	189.3
	Local content of RES investments	797.9	421.8	1089.6	333.8	374.2	2468.3	1449.8	2750.4	3841.4	3382.3	16909.6
	Total impact on employment	921.8	583.0	1328.4	695.7	834.3	3129.9	2799.3	5196.9	7048.7	6814.0	29352.0
Total employment (thousands)		369.1	386.3	407.1	431.5	452.1	450.4	463.7	482.5	496.6	506.7	4446
Impact of RES on the economy as % of GDP		**0.2%**	**0.2%**	**0.3%**	**0.2%**	**0.2%**	**0.7%**	**0.6%**	**1.1%**	**1.4%**	**1.3%**	**0.7%**

Table 5: Aggregate impact on the economy from investments in RES and reduction in fossil fuel imports during the decade 2015-2024, by economic sector.

n/n	NACE Sector	Description	GDP (million Euros)	Labour (no. of jobs)
1	A01, A02, A03	Agriculture	12.3	436.5
2	B	Mining	4.9	81.3
3	C10, C11, C12	Food Manufacturing	43.0	1334.5
4	C13, C15	Textile	15.7	589.5
5	C16, C17, C18	Wood and Paper	2.7	89.2
6	C19 -- C23	Chemical and Plastic Products	14.4	267.8
7	C24 - C25	Metal Products	98.1	2132.7
8	C26 -- C33	Machinery Equipment	505.1	11256.8
9	D	Energy	22.6	325.0
10	E	Water Supply, Treatment	4.4	62.5
11	F	Construction	136.1	3739.1
12	G	Trade	75.4	1756.2
13	H49	Land transport services and transport services via pipelines	7.2	175.4
14	H50	Water transport services	5.8	70.3
15	H51	Air transport services	11.2	325.1
16	H52-H53	Transport Warehousing	7.1	128.0
17	I	Accommodation and food services	83.9	2437.2
18	J	Information and communication	27.3	342.7
19	K	Financial insurance activities	36.0	435.5
20	L	Real Estate	146.0	563.5
21	M	Professional, scientific and technical activities	4.8	78.3
22	N	Administrative and support service activities	4.1	94.9
23	O	Public Administration	18.1	340.3
24	P	Education	23.2	592.2
25	Q	Health	12.9	281.0
26	R-S-T-U	Other services	38.8	1416.6
		Total Impact	**1361.2**	**29352.0**

5. Discussion and Conclusions

At a time of great instability in global energy supply and uncertainty about the future of oil and gas prices, it is evident that countries that are net fossil fuel importers seek independence from fuel imports. This is particularly relevant for European countries that have suffered from oil and gas price spikes since 2022. Apart from investing in energy efficiency, an obvious way out of this dependence is through the faster deployment of green energy. However, this may create new dependencies on suppliers of raw materials and manufactured products that are crucial for the transition to net-zero economies.

The usual discussion in such cases is about the fuel import bill that European countries are undergoing, especially during periods of elevated oil and gas prices. This, however, is only part of the picture. To examine the economy-wide impact of decarbonisation one must account for imports of substitutes and for the impacts of the green transition on economic output across all sectors. We have applied in this paper such an economy-wide approach for Cyprus, a country which relies on imported, high-carbon fossil fuels for its power generation, but – thanks largely to EU energy and climate policies – has made slow but tangible progress towards decarbonisation of its electricity system.

As the transition to carbon neutrality by 2050 requires much faster deployment of green technologies, problems and barriers to decarbonisation receive prominent coverage in the public debate. However, our analysis has shown that renewable energy deployment, although dependent on imported equipment itself, saves the Cypriot economy and society very substantial resources that would otherwise be spent on even more imports of fossil fuels and more purchases of carbon emission allowances for the greenhouse gas emissions of thermal power plants. It also helps reduce some of the air pollution generated by the combustion of fossil fuels in power plants.

We focused on the deployment of renewable electricity in the most recent decade 2015-2024 since we were able to obtain official and consistent statistical data for this period. Essentially all RES investments of this decade involved solar PV panels on rooftops and in commercial PV parks. Instead of making assumptions about the actual utilisation of these investments by year, and of conducting scenario projections for the future, we opted to rely on officially reported actual electricity generation of this period.

The deployment of PV panels yields four kinds of direct benefits: it stimulates the economy by boosting local activity and local labour in sectors related to the installation of solar panels; it reduces the needs for additional imports of fossil fuels for power plants, thereby improving the trade balance; it lowers the GHG emissions of power generation and hence the amount of allowances that need to be purchased from the EU Emissions Trading System which are passed through to retail electricity prices; and it decreases the emissions of air pollutants from power plants thus improving air quality and ameliorating adverse health impacts to the population. On the other hand, the substituted thermal power generation requires imports of PV panels and auxiliary equipment for their operation as well as additional equipment that is necessary to integrate PVs in the transmission and distribution system.

Combining energy, economic and trade statistics with technical calculations, our study has found that already by mid-2025, renewables deployed in Cyprus in the past decade have contributed to the accumulation of very substantial net benefits to the economy, which will continue to accrue in the coming years. The resulting benefit-cost ratio of between 11 and 19 – depending on whether avoided air pollution damages are considered or not – is a clear indication of these benefits. There are hardly any studies conducting a similar analysis which would allow a comparison of our findings, as most relevant studies involve projections into the future, which are fraught with uncertainties – whereas our study is solely based on past data and does not depend on assumptions for the future. For example, the UK Climate Change Committee (2026) reported that for every pound invested in sustainable energy, the benefits outweigh the costs by a factor of 2.2 to 4.1, but these refer to projections until 2050 and include the entire economy, where decarbonisation is more expensive in some sectors like transport and heavy industry, so that the benefits are expectedly relatively lower. The European Commission (2024), in its impact assessment of its 2040 climate target, shows the negative macroeconomic impact of energy price shocks and refers to the co-benefits of decarbonisation, but its rich quantitative analysis does not present directly comparable results with those of our study.

We then applied these estimates of direct impacts to an input-output model that accounts for the linkages of each sector within the economy and found a very significant positive impact, with decarbonisation boosting GDP and employment in Cyprus considerably, and by more than 1% per year from 2023 onwards. These positive effects are equally attributable to the economic stimulus brought about by RES investments and to the improved trade balance that freed up resources for domestic consumption and investments in the economy.

As explained in sections 3 and 4, there are reasons to consider some of the assumptions as underestimation and others as overestimation of costs or benefits. We consider, however, the overall framework and the reported assumptions as a reasonable approximation of the actual impact of RES deployment on the Cypriot economy, and a much more accurate assessment in comparison to EU-wide assessments provided by international organisations with the aid of models that use less granular data.

The above findings refer to the costs and the benefits only from the operation of those RES installed during the decade 2015-2024 in Cyprus, up to the end of their lifetime. This means that the corresponding impact of RES investments before 2015 and those deployed from 2025 onwards are not accounted for here. Pre-2015 effects are comparatively lower because of the low RES deployment at that period. On the other hand, the quantification of post-2024 impacts would need a slightly different assessment from the one presented in this paper for two reasons. First, the electricity system of Cyprus has currently reached a stage where additional investments on renewables require substantial deployment of energy storage and to some extent a further expansion and modernisation of the electricity grid. Second, future RES deployment will yield additional economic benefits because investments in new conventional power capacity will be avoided – in contrast to the situation up to now when the modest progress in RES installations has not helped avoid new conventional power investments.

Therefore, the results we showed in this paper regarding the green investments of the decade 2015-2024 may not immediately apply to future RES investments as the post-2025 calculations will need to consider the above points as well. In any case, deep decarbonisation is expected to yield important and sizeable socioeconomic benefits over the longer term as outlined in another recent study on the net-zero transition of Cyprus (Zachariadis and Taliotis, 2023).

A comment must be made with regard to the environmental impact of renewables, especially from the installation of PV panels and wind farms in high nature value farmland, as well as environmentally sensitive ecosystems and protected areas (e.g. Natura 2000 sites, flyways and migratory routes of birds, forests, wetlands, etc). Our assessment has not considered these impacts, although it is likely that the operation of some PV parks and wind farms has already adversely affected such areas in Cyprus. A detailed bottom-up assessment of individual cases of PV parks and wind farms would be needed for this purpose, as well as a demanding attempt to monetise the environmental impacts in a way similar to the monetisation of the air quality impacts presented in this paper; the latter, however, is based on established methodologies and EU-wide studies, whereas the valuation of natural ecosystems needs a tailored approach that would be appropriate for the specific areas to be studied. A rough approximation by the authors is that the costs of such adverse environmental impacts do not exceed the benefits from improved air quality thanks to RES deployment. This does not mean that adverse impacts can be ignored, but that one can focus on the monetary costs and benefits of this study to appreciate the very positive socioeconomic effects of green investments so far. At the same time, strict implementation of spatial planning and environmental rules for the protection of agricultural land and protected areas will be imperative for the future.

It must also be stressed that this study has observed the impact of RES deployment in an aggregate manner and has not addressed how the economic benefits have been distributed within the Cypriot society. In the absence of real competition in the national electricity market, most citizens and firms have enjoyed much less the advantages of decarbonisation than some market actors. A few private investors in RES parks have obtained large profits during these years. Moreover, households which had sufficient financial resources and space to install rooftop PVs – less than a third of total households in Cyprus – have benefited considerably, whereas citizens that could not afford (or did not have sufficient space in their residences) to install solar panels essentially subsidised the electricity system. Changes in the electricity regulatory regime can spread the benefits of RES deployment to broader parts of society – which is particularly important for households suffering from energy poverty that may also be disproportionately vulnerable to deteriorating climatic conditions.

The European Central Bank has recently underlined that green energy strengthens macroeconomic stability and supports economic growth and Europe’s strategic autonomy[6]. Our analysis confirms these findings, and we consider this approach appropriate to be applied in any country. At the same time, it is important to note that the application of our method in Cyprus offered analytical advantages. First, the country does not have a significant fossil fuel sector since it neither possesses indigenous fossil energy resources nor does it have oil refining capacity – it imports all its oil in the form of final products from abroad. Second, we have analysed a period in which RES penetration has been small to modest; therefore, it was safe to assume that activities around storing and distributing oil to the thermal power plants did not suffer any serious setback in their economic output and there were no stranded assets. Applying this method to other countries may require considering other channels of positive and negative impact in addition to those depicted in Figure 1. Still, the granular approach presented here minimises the uncertainties and assumptions that are necessary to run more sophisticated economic models, and thus can offer credible and valuable insights on the economy-wide impact of strengthening national energy security through decarbonisation policies.

[6] Blog post of Frank Elderson, Member of the Executive Board of the ECB, 7 April 2026.

References

Armington, P. S. (1969). A Theory of Demand for Products Distinguished by Place of Production (Une théorie de la demande de produits différenciés d'après leur origine) (Una teoría de la demanda de productos distinguiéndolos según el lugar de producción). Staff Papers-International Monetary Fund, 159-178.

Blanchflower, D. G., Oswald, A. J., & Sanfey, P. (1996). Wages, profits, and rent-sharing. *The Quarterly Journal of Economics*, 111(1), 227-251. https://doi.org/10.2307/2946663

Borozan, D. (2025). Assessing the impact of geopolitical risk, energy import dependence, and economic policy uncertainty on energy consumption. *Energy Efficiency* 18, 59. https://doi.org/10.1007/s12053-025-10340-2

Card, D., Cardoso, A. R., Heining, J., & Kline, P. (2018). Firms and labor market inequality: Evidence and some theory. *Journal of Labor Economics*, 36(S1), S13-S70. https://doi.org/10.1086/694153

Corden, W. M., & Neary, J. P. (1982). Booming sector and de-industrialisation in a small open economy. *The Economic Journal*, 92(368), 825-848. https://doi.org/10.2307/2232670

Dolphin, G., Duval, R., Rojas-Romagosa, H., Sher, G. (2024). The Energy Security Gains from Strengthening Europe’s Climate Action. Departmental Paper DP/2024/005. Washington, DC : International Monetary Fund. https://doi.org/10.5089/9798400265655.087

Dynan, K. E., Skinner, J., & Zeldes, S. P. (2004). Do the rich save more? *Journal of Political Economy*, 112(2), 397-444.

Ember (2025). *Shockproof: how electrification can strengthen EU energy security*. https://ember-energy.org/latest-insights/shockproof-how-electrification-can-strengthen-eu-energy-security/#executive-summary – last accessed on 17 April 2026.

European Commission (2024). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, *Securing our future: Europe's 2040 climate target and path to climate neutrality by 2050 building a sustainable, just and prosperous society*. Document SWD(2024) 63 final, Strasbourg, February. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2024:63:FIN

European Commission (2026). *Energy prices and costs in Europe*. https://energy.ec.europa.eu/data-and-analysis/energy-prices-and-costs-europe_en - last accessed on 16 April 2026.

European Environment Agency (2023). EMEP/EEA air pollutant emission inventory guidebook 2023. EEA Report 06/2023, Copenhagen. https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023 - last accessed on 30 March 2026.

European Union (2021). Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 (‘European Climate Law’). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R1119

Eurostat (2008). Statistical classification of economic activities in the European Community. NACE Rev. 2. Office for Official Publications of the European Communities, Luxembourg.

Eurostat (2025a). Domestic net greenhouse gas emissions - https://doi.org/10.2908/SDG_13_10 - last updated on 20 January 2026.

Eurostat (2025b). *Key figures on Europe – 2025 edition*, July 2025 – https://doi.org/10.2785/0857421 - last accessed on 30 March 2026.

Eurostat (2025c). EU greenhouse gas footprint - https://doi.org/10.2908/CLI_GGE_FOOT - last updated on 23/01/2026.

Eurostat (2025d). Renewable energy statistics - https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Renewable_energy_statistics – last updated on 16 December 2025.

Eurostat (2026a). Energy in Europe: imports dependency. https://ec.europa.eu/eurostat/web/products-eurostat-news/w/wdn-20260318-1 - last updated on 18 March 2026.

Eurostat (2026b). Symmetric input-output table at basic prices (product by product) [naio_10_cp1700] – https://doi.org/10.2908/NAIO_10_CP1700 - last accessed on 30 March 2026.

Eurostat (2026c). Gross value added and income by detailed industry (NACE Rev. 2) [nama_10_a64] - https://doi.org/10.2908/NAMA_10_A64 - last accessed on 30 March 2026.

Eurostat (2026d). Capital formation by industry (NACE Rev.2) and detailed asset type [nama_10_a64_p5] - https://doi.org/10.2908/NAMA_10_A64_P5 - last accessed on 30 March 2026.

Eurostat (2026e). SHARES (Short Assessment of Renewable Energy Sources) database. https://ec.europa.eu/eurostat/web/energy/database/additional-data - last accessed on 17 April 2026.

Fazzari, S., Hubbard, R. G., & Petersen, B. C. (1987). Financing constraints and corporate investment. NBER Working Paper 2387.

FEEM (2008), CASES (Cost Assessment for Sustainable Energy systems) https://cordis.europa.eu/project/id/518294/reporting - last accessed on 20 April 2026.

International Energy Agency (2023). Overcoming the Energy Trilemma: Secure and Inclusive Transitions. IEA report to G7 Leaders, Paris, December. https://www.iea.org/reports/overcoming-the-energy-trilemma-secure-and-inclusive-transitions - last accessed 16 April 2026.

International Energy Agency (2025a). *Global EV Outlook 2025*, Paris, France. https://www.iea.org/reports/global-ev-outlook-2025 - last accessed on 30 March 2026.

International Renewable Energy Agency (2025b). *Renewable power generation costs in 2024*. https://www.irena.org/Publications/2025/Jun/Renewable-Power-Generation-Costs-in-2024 = last accessed on 30 March 2026.

Katz, L. F., Summers, L. H., Hall, R. E., Schultze, C. L., & Topel, R. H. (1989). Industry rents: Evidence and implications. Brookings Papers on Economic Activity. Microeconomics, 1989, 209-290.

Miller, R. E., & Blair, P. D. (2009). *Input-output analysis: foundations and extensions*. Cambridge University Press. https://doi.org/10.1017/CBO9780511626982

Opler, T., Pinkowitz, L., Stulz, R., & Williamson, R. (1999). The determinants and implications of corporate cash holdings. *Journal of Financial Economics*, 52(1), 3-46. https://doi.org/10.1016/S0304-405X(99)00003-3

Piketty, T., & Saez, E. (2003). Income inequality in the United States, 1913–1998. *The Quarterly Journal of Economics*, 118(1), 1-41. https://doi.org/10.1162/00335530360535135

Republic of Cyprus (2020), Integrated National Energy and Climate Plan, Nicosia, January. https://energy.ec.europa.eu/system/files/2020-01/cy_final_necp_main_en_0.pdf - last accessed 30 March 2026.

Republic of Cyprus (2024), Final Updated National Energy and Climate Plan, Nicosia, December. https://commission.europa.eu/publications/cyprus-final-updated-necp-2021-2030-submitted-2024_en - last accessed 30 March 2026.

Schreyer, F., Ueckerdt, F., Pietzcker, R. et al., 2025. From net-zero to zero-fossil in transforming the EU energy system. *Nature Communications* 16, 10700. https://doi.org/10.1038/s41467-025-66682-z

SolarPower Europe (2026). *Solar & Storage for EU Energy Security*. Briefing Paper, April. https://www.solarpowereurope.org/insights/thematic-reports/solar-and-storage-for-eu-energy-security - last accessed on 17 April 2026.

Taliotis, C., Giannakis, E., Karmellos, M., Fylaktos, N., & Zachariadis, T. (2020). Estimating the economy-wide impacts of energy policies in Cyprus, *Energy Strategy Reviews* 29, 100495. https://doi.org/10.1016/j.esr.2020.100495

Transmission System Operator of Cyprus (2026). Annual reports available at https://tsoc.org.cy/organization/annual-reports/ - last accessed 30 March 2026.

UK Climate Change Committee (2026). *Supplementary analysis of the Seventh Carbon Budget*, March. https://www.theccc.org.uk/publication/supplementary-analysis-of-the-seventh-carbon-budget/ - last accessed 21 April 2026.

Zachariadis, T. & Taliotis, C. (2023). The Cyprus Economy's Path to Climate Neutrality: Energy Scenarios, Economic Impacts and Policy Proposals. The Cyprus Institute, Nicosia, December (in Greek, with Executive Summary in English). https://www.cyi.ac.cy/images/stedi-rc/CyI_NetZero_Dec2023.pdf

ANNEX

Table A1. NACE (statistical classification of economic activities in the European Union) codes of the sectors of economic activity that make up the 26 sectors for the input-output analysis.

n/n	Sector	Description NACE
1	A01, A02, A03	Agriculture
2	B	Mining
3	C10, C11, C12	Food Manufacturing
4	C13, C15	Textile
5	C16, C17, C18	Wood and Paper
6	C19 -- C23	Chemical and Plastic Products
7	C24 - C25	Metal Products
8	C26 -- C33	Machinery Equipment
9	D	Energy
10	E	Water Supply, Treatment
11	F	Construction
12	G	Trade
13	H49	Land transport services and transport services via pipelines
14	H50	Water transport services
15	H51	Air transport services
16	H52-H53	Transport Warehousing
17	I	Accommodation and food services
18	J	Information and communication
19	K	Financial insurance activities
20	L	Real Estate
21	M	Professional, scientific and technical activities
22	N	Administrative and support service activities
23	O	Public Administration
24	P	Education
25	Q	Health
26	R-S-T-U	Other services

Source: Eurostat (2008).

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