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Environmental and Economic Impacts of the National Energy and Climate Plan of Cyprus

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Abstract

This paper provides a summary of the Impact Assessment of the National Energy and Climate Plan of Cyprus, which was submitted by the Cypriot government to the European Commission in January 2020. The analysis is based on detailed modelling of the national energy system in combination with simulations by macroeconomic and household demand models. The study has produced numerous results describing the energy, environmental and economic impacts of different scenarios. This paper focuses on some key findings and recommendations that are of interest to economic policy makers. Results show that the planned energy and climate policies of the Cypriot government, while contributing to compliance of Cyprus with its legally binding energy and environmental obligations, can also yield economic benefits to society. However, they require strong political will to implement, and this especially applies to measures promoting sustainable transport. As further decarbonisation measures will be needed in the coming years, the country can exploit business and investment opportunities arising from the global energy transition.

Keywords: Decarbonisation, Emissions Abatement, Greenhouse Gases, Input-Output Model, Renewable Energy.

1. Introduction

Governments around the world declare energy- and climate-related targets for the medium and long term in order to bring their policies in line with the Paris Agreement on Climate Change, which was adopted in 2015 (UNFCCC, 2015). The European Union has the most ambitious policy in this field, with specific legally binding objectives by the year 2030 and a commitment for achieving 'net zero' greenhouse gas emissions by 2050 which is planned to become legally binding before the end of 2020. To meet the EU's energy and climate targets, EU Member States had to establish and submit by the end of 2019 a ten-year national energy and climate plan (NECP) for the period from 2021 to 2030. Rules about this obligation are determined by the Regulation on the Governance of the Energy Union and Climate Action (EU/2018/1999).

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NECPs describe how each country intends to address issues related to energy efficiency, renewable energy, greenhouse gas emissions reductions, cross-country connections of electricity grids and research related to climate stabilisation. According to the above mentioned Regulation, the NECP should be accompanied by an impact assessment that focuses on the impact of national policies on energy use, greenhouse gas emissions, health, macroeconomic development, employment, social equity, investment needs and regional cooperation.

This paper summarises key findings from the impact assessment of the NECP of Cyprus, which was carried out as a separate study that was incorporated in the final NECP which was submitted to the European Commission in January 2020. We outline the combination of energy and economic models used for this purpose, the scenarios considered and some of the main results. Section 6 concludes with the main policy recommendations. The full reports of this study are available on the webpage of the Ministry of Energy, Commerce, Industry and Tourism (Zachariadis et al., 2019a; 2019b), while the full NECP is available on the webpage of the Ministry of Agriculture, Rural Development and Environment (Republic of Cyprus, 2020).

2. Methodology

To analyse energy, environmental and diverse economic impacts, we employed four computational models which were soft-linked, i.e. output of some of the models was used as input to others. As it is not possible to explore all possible environmental and economic impacts with one model that would represent the energy system, the national economy and the income structure of households with reasonable accuracy, using a combination of computational models is a frequent practice in the related literature (see e.g. Rocco et al., 2018; Siala et al., 2019). In the case of Cyprus the impact assessment was implemented as follows:

- An energy forecast model was used to project final energy demand in the residential, commercial, industrial and agricultural sectors of the Cypriot economy. This model has been used to support national energy strategies in the past (Zachariadis and Taibi, 2015). It uses projections of national GDP and international oil prices, along with assumptions on the short-term and long-term income and price elasticities of energy demand (IRENA, 2015). Apart from energy demand forecasts per year, the model provides forecasts of the annual energy consumption expenditure of households, which are entered to the dynamic input-output model described below to estimate the multiplier effect of changes in private consumption in the economy of Cyprus.
- A dynamic cost-optimisation model was employed to project the technology and energy mix in the electricity supply and transport sectors. It was developed within the Open-Source Energy Modelling System (OSeMOSYS), which is a long-term cost-optimisation energy system model that has been used in numerous international studies (Howells et al., 2011). It is a bottom-up demand-drive model that determines the optimal energy mix and technology choice per year, with the objective to minimise total discounted system cost over the entire modelling horizon subject to technical and environmental constraints.

- The projected levels of energy-related investments across the economy and the associated costs for operation and maintenance of all technology options, are fed by the cost-optimisation model to the IO model to estimate the economy-wide impacts on economic growth across the different sectors of the local economy. Input-Output (IO) analysis studies the interdependence of production sectors in an economy over a stated time period and is extensively applied for policy impact evaluation, including energy and environmental analysis (Miller and Blair, 2009).
- Changes in retail energy prices, which are the output of the demand forecast model and the optimisation model, are used as input in a household demand model that has been econometrically estimated on the basis of Family Expenditure Surveys of Cyprus (Pashardes et al., 2014). The model was used to simulate the welfare effects of price increases on households grouped by income, location and demographic characteristics.

Further details about the first three models are provided by Taliotis et al. (2020).

3. Scenarios considered

Following the guidelines of Regulation EU/2018/1999 about national NECPs, we considered two main scenarios: a Scenario 'With Existing Measures' (WEM) and a Scenario 'With Planned Policies and Measures' (PPM).

The WEM scenario assumes a continuation of the policies that have already been adopted by the government of Cyprus, either in implementation of EU policies or as national initiatives. Power generation is considered to shift to natural gas by the end of 2021, in line with national plans, renewable energy penetration and energy efficiency improvements in buildings and industry are assumed to continue at the current pace, and small interventions in the road transport and agriculture are taken into account.

The PPM scenario assumes stronger energy efficiency measures in buildings and industry, induced by diverse financial incentives that facilitate energy renovations, a faster penetration of renewable energy in electricity production. Most importantly, in line with political decisions taken by the Transport Ministry, it assumes a substantial shift from private cars to public transport modes (buses and a tram system for Nicosia), as foreseen in Sustainable Urban Mobility Plans that are under preparation for all cities of Cyprus. PPM includes two variants – one assuming that the electricity interconnection of Cyprus with Greece and Israel (EuroAsia Interconnector) will proceed as planned and become operational by the year 2024, and one assuming that the interconnection project will not be implemented at least until 2030. The variant without interconnection was the one that was officially used by national authorities as the PPM scenario of the NECP that was submitted to the European Commission.

A more detailed description of the policies and measures included in each scenario is provided in the NECP (Republic of Cyprus, 2020) and as an Appendix of the Impact Assessment study (Zachariadis et al., 2019a).

4. Summary of the results and comparison of scenarios

The main reports of the impact assessment study present detailed results of each scenario, as regards the demand for primary and final energy in Cyprus up to 2030 and 2050, the outlook for emissions of greenhouse gases and air pollutants, macroeconomic and employment impacts, monetised health effects, impacts on the cost of living of households by income group, and regional effects. This section attempts to distil the detailed results and provide the major findings that arise from the scenarios that were considered in the study. We emphasise results that would be of interest to economic policy makers; for detailed information about the projected energy mix and the evolution of environmental indicators, interested readers are referred to the corresponding chapters of the full Impact Assessment study (Zachariadis et al., 2019a; 2019b), or to the full NECP report (Republic of Cyprus, 2020).

4.1. Investment needs

The scenarios of the Cyprus NECP have very similar requirements for total investments in the energy system. However, the aggregate figures hide significant differences in the kind of investments needed. Table 1 presents these differences in estimated investment needs between the WEM and PPM scenarios.

TABLE 1

Cumulative additional investment needs in the period 2020-2030 to implement the PPM scenario without the EuroAsia Interconnector, in comparison to the WEM scenario

Sector	Difference in investments (mio Euros' 2016)	% of total GDP of 2021-2030
Power generation (new thermal power plants, photovoltaics etc.)	-46	-0.02%
Electricity storage technologies (pumped hydroelectric storage & batteries)	-72	-0.03%
Sustainable Mobility (buses & tram, bus lanes, cycle lanes etc.)	1378	0.48%
Private transport (shift to sustainable transport modes, more efficient cars, electric cars, biofuels etc.)	-2098	-0.73%
Residential & commercial buildings (energy efficiency renovations)	715	0.25%
Industry (replacement of machinery, boilers etc.)	77	0.03%
Total Additional Investments	**-46**	**-0.02%**

More specifically, the power generation and electricity storage sector needs fewer investments in the PPM Scenario because energy efficiency measures reduce the demand for electricity compared to WEM. Enabling a significant modal shift towards sustainable modes of transport is an important ingredient of a serious decarbonisation policy, and this is reflected in the PPM Scenario. The purchase of new, clean buses and the construction of a tram line are costly measures, with investments expected to

exceed 1.3 billion Euros'2016. However, these additional investment needs – which are expected to be covered by the national budget and perhaps partly through EU funds – are counterbalanced by the decline in purchases of new vehicles, which saves (mainly private) expenditures of about 2 billion Euros'2016 throughout the 2020-2030 period. These very substantial savings account for 15-20% of the annual purchase costs of new cars foreseen in the WEM Scenario.

Energy renovations in buildings of the residential and tertiary sector, if implemented actively up to an extent that is considered realistic in Cyprus, will require by the year 2030 additional investments of about 715 million Euros. This amount is expected to come from a combination of public and private investments and is the result of extensive data collection and discussions with national energy authorities in the frame of studies that were carried out during the last years; this amount is consistent with the level of achievable energy savings in households and services which have been calculated in the PPM scenario. Similarly, investments in industry to reach realistic energy savings foreseen in this scenario amount to 77 million Euros'2016 for the period 2020-2030.

In total, as shown in Table 1, implementation of the PPM scenario is projected to lead to slightly lower economy-wide investments for the period up to 2030 (46 million Euros'2016 less) than those foreseen in the WEM Scenario. The main reason for this drop in investment needs is the substantial decline in the expenditures for new cars because of the significant shift towards public and non-motorised transport foreseen in this scenario. This counterbalances the amount of investments required for promoting public transport, cycling and walking through the implementation of Sustainable Urban Mobility Plans that the government of Cyprus is currently preparing. Is it worth mentioning that, in the absence of the sustainable transport measures foreseen in the PPM scenario, the private car stock would increase by about 20% in comparison to the 2018 vehicle fleet levels, whereas in the PPM scenario the growth in motor vehicle fleet is mitigated, so that the number of cars remains up to 2030 at the levels of year 2018.

Out of the investments shown in Table 1, those for private transport are expected to come from private sources, whereas those for sustainable transport modes are expected to come from public funds. As regards buildings and industry, it should be expected that about half of the amount will come from public funds in order to mobilise an equal amount of private funds for energy renovations and replacement of equipment, appliances and machinery. This is in line with the experience obtained by national authorities from the implementation of energy efficiency subsidy schemes during the last years. As a result, it should be expected that about 1.4 billion Euros for sustainable transport investments and about 400 million Euros for renovations in buildings and industrial plants will have to be funded from the government budget, or from EU funds. The sum of public investments of 1.8 billion Euros'2016 may seem a big amount, but still it does not exceed 0.7% of the total projected GDP of Cyprus for the decade 2021-2030. This means that public investments of such size are feasible for the Cypriot economy. However, the fiscal implications should be treated with care if such an amount is to be entirely funded from the public budget; it is therefore advisable that a considerable portion of this amount comes from EU funds such as the EU Structural Funds or loans from the European Investment Bank.

An appraisal of the cost-effectiveness of these investments is provided in Section 4.3 below.

4.2. Assessing costs and benefits

Table 2 displays a summary of the projected change in total energy system costs of the PPM scenario in comparison to the corresponding costs of the WEM scenario. Cost differences are presented for each main group of measures that are included in the PPM scenario: power generation, electricity storage, measures for promoting public and non-motorised transport, measures related to motor vehicles, and policies related to energy efficiency improvements in buildings and industry[1].

Cost differences are presented separately for investment costs and operation & maintenance costs; the latter also include fuel costs, and in many cases these are negative, reflecting the savings in fuel expenditures that can be achieved in the case of energy efficiency measures in transport, buildings and industry. Note that fuel costs that were included in these calculations are net of taxes and duties in order to reflect the societal effect from the reduction of fuel import costs. At the end of the table we have added the economic benefits foreseen due to reduced damages from air pollution, in line with an appraisal of environmental costs by scenario that was conducted in the frame of the impact assessment study.

It is evident from Table 2 that the policies and measures foreseen in the PPM scenario are expected to be beneficial to society. Total benefits, including the environmental ones, are over 500 million Euros'2016 by 2030, representing 1.6% of the country's projected GDP in that year. The additional investments, especially in energy efficiency measures and sustainable transport modes, although designed to be effective over a longer time horizon, pay off already by the end of the decade: fuel cost savings in buildings and industry as well as reduction in the purchase and use of private cars lead to a substantial decrease in operation costs and therefore to the total energy system costs. The benefits become also somewhat larger thanks to the improvements in air quality and the associated benefits from lower health impacts.

One might argue that these results are optimistic because of the projected strong reduction in the fleet of passenger cars, which leads to much lower investments for private transport in the PPM scenario. However, if one observes the figures of Table 2, it is evident that energy system costs are lower even if investments in private transport do not decrease. This points to a clear conclusion that the implementation of Planned Policies and Measures will be beneficial to society, leading to a reduced fuel import bill and improved air quality. This finding is in line with international evidence, such as the analysis of the carbon neutrality objective made by the European Commission (2018) as well as assessments by the World Bank (2014) or other organisations (e.g. Coalition for Urban Transitions, 2019).

The above conclusion is valid as long as the policies and measures foreseen in the PPM scenario are actually realised. There are financial and behavioural barriers that may

[1] Construction of the electricity interconnector is not included because the PPM scenario that was adopted by the national authorities does not assume implementation of electricity interconnection. The corresponding table that includes construction of the interconnector is available in Zachariadis et al. (2019b; p. 6).

delay or cancel the deployment of some of these measures. However, our analysis shows that the government of Cyprus should proceed with these measures as they seem to be the only way for the country to approach its long-term energy and climate policy commitments, and at the same time can yield economic benefits to society.

TABLE 2

Projected change in energy system costs in Cyprus according to the PPM scenario without electricity interconnection, in comparison to the WEM scenario.

Sector	Costs (mio Euros'2016)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Power Generation (new thermal and renewable power plants)	Investment	63	82	64	64	43	40	12	10	11	21
	Operation & Maintenance	-2	-6	-7	-12	-16	-5	-5	-10	-29	-41
	Total	**61**	**77**	**57**	**53**	**27**	**35**	**6**	**0**	**-17**	**-20**
Electricity storage technologies (pumped hydro & batteries)	Investment	0	0	0	0	-3	-3	-16	-16	-16	-18
	Operation & Maintenance	0	0	0	0	0	0	-2	-2	-2	-2
	Total	**0**	**0**	**0**	**0**	**-3**	**-3**	**-19**	**-19**	**-19**	**-21**
Sustainable mobility (buses & tram, cycle lanes, bus lanes etc)	Investment	29	50	71	92	113	135	156	215	258	250
	Operation & Maintenance	2	4	6	8	10	12	14	16	18	20
	Total	**31**	**54**	**77**	**100**	**124**	**147**	**170**	**231**	**276**	**270**
Private transport (shift to sustainable transport modes, more efficient cars, electric cars, biofuels etc.)	Investment	-43	-83	-126	-165	-202	-234	-243	-291	-336	-374
	Operation & Maintenance	-33	-66	-100	-134	-174	-214	-278	-301	-334	-394
	Total	**-75**	**-149**	**-226**	**-299**	**-376**	**-448**	**-522**	**-592**	**-670**	**-768**
Energy efficiency improvements (buildings & industry)	Investment	72	72	72	72	72	72	72	72	72	72
	Operation & Maintenance	-3	-6	-7	-10	-16	-20	-26	-30	-32	-34
	Total	**69**	**66**	**65**	**62**	**56**	**52**	**46**	**42**	**40**	**38**
Difference in Total System Costs	Investment	122	121	82	63	24	11	-20	-11	-11	-50
	Operation & Maintenance	-36	-74	-109	-148	-196	-228	-297	-327	-380	-452
	Total	**85**	**47**	**-27**	**-85**	**-172**	**-217**	**-317**	**-337**	**-391**	**-501**
Difference in Environmental Costs		**-2**	**-3**	**-5**	**-6**	**-7**	**-8**	**-9**	**-10**	**-11**	**-12**
Difference in Total System Costs Including Environmental Costs		**84**	**44**	**-31**	**-91**	**-179**	**-225**	**-326**	**-347**	**-402**	**-513**

4.3. Ranking of policies and measures according to their cost-effectiveness

Which measures should be prioritised among those included in the list of Planned Policies and Measures? A first answer could be that all measures have to be implemented because, as shown the NECP of Cyprus, even their full deployment is not sufficient to make Cyprus comply with all legally binding targets of greenhouse gas emission reductions. However, as public policy always has to take into account practical or political constraints, it is still useful to provide recommendations about the costs and emissions abatement potential of each measure.

Such an analysis can only partly be made with models like OSeMOSYS, because it requires detailed 'bottom-up' information on each technology or measure, which is not always available in energy system models. We therefore report in this section some additional results of an earlier study (Sotiriou et al., 2019) which are consistent with those used in the OSeMOSYS model and in the previous sections of this paper. The study focused on emission reduction measures in final energy demand sectors (i.e. power generation was not included) and led to the construction of a baseline and several alternative marginal emission abatement cost curves. Nationally appropriate data were collected from earlier studies and from the local market. The results of this detailed analysis showed that the most cost-effective measures are the following:

- Roof insulation in pre-2008 residential multi-family buildings;
- The installation of heat pumps in pre-2008 residential buildings;
- Cogeneration in the industrial and tertiary sector;
- Increased use of anaerobic digestion for animal waste to produce biogas;
- Replacement of oil-fired burners in industry.

Measures that are not recommended to deploy because they have a very high cost per tonne of carbon abated are the renovation of very old buildings to become nearly-zero energy buildings, and wall insulation of pre-2008 buildings. All other measures are worth investing in, and most of them lead to negative social costs, which means that they yield benefits to society because the fuel cost savings during the lifetime of these investments outweigh the initial investment costs. The benefits are even stronger if the reduction in health damages because of lower air pollutant emissions are also taken into account.

However, at a realistic rate of building and equipment renovations, many of the above cost-effective measures have a relatively limited potential to reduce emissions up to 2030. Therefore, it is absolutely necessary to proceed with policies for decarbonising road transport, i.e. with the promotion of public and non-motorised transport and the electrification of the car fleet. Only these measures can yield significant emission reductions, and although they seem to be more costly than others, they are beneficial to society if all their benefits are taken into account.

As regards the justification of measures that are included in the PPM scenario of this Impact Assessment study and are related to power generation and electricity storage, it is clear that they are necessary for reaching the corresponding legally binding obligations of Cyprus as regards greenhouse gas emission reductions and renewable energy penetration as explained in Zachariadis et al. (2019a).

Apart from the measures described above, which relate to energy use, agriculture and waste, additional options are included in the PPM Scenario, namely a) the proper recovery of fluorinated gases in industrial equipment and b) afforestation. Based on information available to the authors, as explained in Zachariadis et al. (2019b), fluorinated gas recovery passes the cost-effectiveness test and is worth pursuing, while the outlook is mixed for afforestation: Costs per unit of carbon reduced are high for trees that are planted in 2019-2022 with a view to achieving emission reductions up to 2030. However, if one keeps in mind that trees have a very long lifetime and will absorb higher amounts of carbon dioxide when they grow further, this measure can be considered as important in the longer term.

Using all available information, Zachariadis et al. (2019b) concluded that most policies and measures considered in the PPM scenario pass the cost-effectiveness test as their costs are lower than the central estimates of damage costs of GHG emissions (also called the 'social cost of carbon'), which are around 40 Euros'2015 per tonne (IWG, 2013). Especially if the economic benefits due to reduced emissions of air pollutants are taken into account, most measures show a negative social cost, which means that they yield net benefits to society and are therefore particularly worth implementing immediately. The only sector for which cost-effectiveness is not clear is that of solid waste management, where important measures have to be taken for proper treatment of municipal waste, as outlined in the relevant section of the Cyprus NECP. As regards afforestation, it seems to be a beneficial measure in the long term; it has to be noted, however, that national authorities may have underestimated the costs of afforestation and possibly also overestimated its emission abatement potential in Cyprus.

5. Policy recommendations

Taking into account that national authorities of Cyprus have decided to proceed in their energy and climate policy in three stages (Stage 1 to implement all PPMs until 2022, Stage 2 to employ additional PPMs based on the progress of stage 1; and Stage 3 being an intention to proceed with more ambitious measures in the near future in order to fill the gap towards the -24% emission reduction target), the main policy-relevant findings of the Impact Assessment study can be summarised as follows:

- Existing policies and measures (Stage 1 of the national climate policy) are clearly insufficient to lead Cyprus to compliance with its obligations stemming from the Energy Union Governance Regulation. They cannot lead to compliance with the national renewable energy and energy efficiency targets, and can only lead to a small reduction in greenhouse gas emissions in 2030 compared to 2005; this will require purchasing a significant amount of emission allowances to fill the 2030 emissions gap, which will cost the Republic of Cyprus at least several million Euros in the period up to 2030. Moreover, non-compliance with the 2030 target for the share of renewable energy in transport will lead to additional costs in the WEM scenario, because the gap in this sector will also have to be covered through costs due to employing a procedure of 'Statistical Transfer' of renewable energy credits foreseen in the EU legislation.
- The Planned Policies and Measures scenario (Stage 2 of the national climate policy), which has been agreed by governmental authorities and is included in the NECP, enables Cyprus to meet its goals regarding energy efficiency and penetration of renewable energy sources. If fully implemented, as shown in Table 2, these measures will lead to net economic benefits to the society of more than 500 million Euros'2016 by 2030.

- According to the macroeconomic simulations with the Input-Output model of the Cypriot economy, implementation of the PPM scenario will lead to small positive effects on economic indicators – a 0.3% increase in national GDP and a 0.3% rise in economy-wide employment in 2030. Construction and metal product manufacturing may be among the sectors to benefit from these policies and measures, due to a higher number of energy renovations and promotion of products related to public transport. The sector of conventional power generation as well as some trade activities (imports of vehicles and liquid fuels) may be among the sectors to lose from the transition to a low-carbon economy as foreseen in the PPM scenario.
- The changes in energy costs to end consumers will be very small; it is expected that electricity prices and automotive fuel may rise by 1.5% in the PPM scenario compared to the WEM scenario. These will have essentially no adverse impact on the welfare of households and social equity. If electricity interconnection is implemented then electricity prices are expected to drop, thereby bringing benefits to low-income groups.
- Road transport holds the key to emissions abatement both for 2030 and for the longer term. Investments in sustainable mobility may exceed 1.3 billion Euros throughout the 2020-2030 period and can therefore be considered as costly. However, these investments are expected to fully pay off because of multiple benefits from the reduction of the use of passenger cars, which can yield aggregate economic benefits to society of the order of over 4 billion Euros'2016. Coupled with a fast electrification of the passenger car sector, they seem to be the only way to achieve the 2030 greenhouse gas emission reduction target and shift the whole Cypriot economy to a low-carbon path towards 2050.
- There are essentially no higher investment requirements to realise the PPM scenario, but a re-allocation towards public investments for sustainable transport; these are expected to pay off because fuel import costs throughout the lifetime of these measures may decline considerably due to these investments.
- However, successful implementation of the package of Planned Policies and Measures is not guaranteed because it requires significant investments for energy renovations in buildings and industry and – most importantly – a substantial commitment to promote public transport and non-motorised transport modes (walking and cycling) as well as a shift to electric cars.
- Among the list of Planned Policies and Measures, some measures are more cost-effective than others (e.g. roof insulation or installation of heat pumps in buildings). However, with very few exceptions, all other measures pass the cost-effectiveness test and can be deployed without delay.
- Non-energy-related measures can also contribute to emission reductions. Recovery of fluorinated gases seems to be cost-effective, while extensive planting of trees may be a measure with relatively limited potential and high cost up to 2030, but is an important ingredient of decarbonisation policy in the longer term.
- In the event that the project of electricity interconnection of Cyprus with Greece and Israel is realised, penetration of renewable energy will be considerably higher. This will enable substantial additional investments for decarbonising the electricity system and will enable Cyprus to stay on track for meeting its long-term decarbonisation targets.
- On the way to decarbonisation of the energy system, research and innovation can play an important role. Although great technological breakthroughs are unlikely to come from

research in Cyprus alone, the existence of a critical mass of researchers in topics such as energy efficiency, renewable energy sources and fuels, and emission abatement measures can accelerate a) the demonstration and deployment of novel technologies in Cyprus, b) the implementation of innovative measures under the particular conditions of the Cypriot market, and c) the development of expertise for innovative services related to low-carbon technologies.

- Even if implemented fast and effectively, Stage 2 (Planned Policies and Measures) falls short of meeting the required greenhouse gas emission reduction target by 2030. In order to achieve full compliance, the government of Cyprus may implement stronger emission abatement policies and measures (e.g. double the number of energy renovations of buildings, increase cogeneration plants or biogas production plants from waste, encourage accelerated replacement of conventional cars with electric ones); however, all these measures are extremely difficult to implement at such a scale within the short time frame available; therefore they cannot be considered as a realistic alternative. Alternatively, energy conservation measures can be induced through the adoption of a fiscally neutral green tax reform, by imposing a gradually increasing carbon tax on all non-ETS sectors. The revenues of such a tax can be recycled in the economy by reducing labour taxes and providing financial support to energy conservation and green transport policies. Such a reform can have substantial economic benefits without harming low-income households or the competitiveness of firms (Zachariadis, 2019).
- In view of the declared political commitment of the European Union to carbon neutrality by 2050, the measures foreseen in the NECP of Cyprus and the options mentioned above for filling the non-ETS emissions abatement gap have to be assessed in light of the need for deep decarbonisation. It has been shown that it is impossible to attain the 2050 target if there is low ambition about decarbonisation in 2030 (Sotiriou and Zachariadis, 2019; Vogt-Schilb and Hallegatte, 2017). Therefore, purchasing allowances to fill the 2030 emissions gap, even if it turns out to be a low-cost option, is not consistent with deep decarbonisation towards 2050; instead it locks the Cypriot economy to an unsustainable path.
- Moreover, the European Commission is expected to announce stronger emission reduction requirements already for 2030 in order to be consistent with the long-term target of net zero carbon emissions for 2050; therefore, the measures of the PPM scenario will be insufficient to meet the increasingly ambitious EU policy targets.
- In September 2019 the Finance Minister of Cyprus announced that a green tax reform will be put in consultation in 2020 with the aim to adopt the relevant legal framework and implement such a reform in 2021. As this measure is still provisional and no specific details have been agreed, it has not been included by authorities in the Planned Policies and Measures scenario of the NECP. Based on the previous considerations outlined in this section, the gradual implementation of a green tax reform from 2021 onwards (Stage 3) seems to be a necessary additional policy, both for leading Cyprus to achievement of the emission reduction target of 2030 and for enabling the transition to a net-zero-carbon economy by 2050.

6. Conclusions

This paper has provided a summary of the Impact Assessment of the National Energy and Climate Plan of Cyprus, which was submitted by the Cypriot government to the European Commission in January 2020. The analysis has been based on detailed modelling of the energy system of the country, which was mainly conducted with the OSeMOSYS optimisation model. Final energy demand projections for sectors other than road transport have been derived from a separate demand forecast model, which were then input to OSeMOSYS. The optimisation results, along with the associated costs and calculated emissions of greenhouse gases and air pollutants, have been fed into other models in order to assess the macroeconomic, employment and distributional impacts of the scenarios that were explored. Apart from the above energy-related data and results, information about emissions abatement and costs for non-energy-related emissions were obtained or estimated in order to assess the cost-effectiveness of all decarbonisation options that are included in the government's policies and measures.

The study has relied on a wealth of technical and economic data from various national and international sources, and has produced numerous results describing the calculated energy, environmental and economic impacts of different scenarios. This paper has focused on some key results that would be of interest to economic policy makers, mainly those related to the investment needs, the cost-benefit assessment of scenarios – which has not been conducted before with Cypriot data – and the cost-effectiveness evaluation of individual policies and measures. For more detailed documentation and presentation of results the reader is directed to the relevant technical reports.

Section 5 of the paper provided a list of recommendations for policy makers. In summary, the policies adopted at European level in order to avoid serious anthropogenic climate change pose significant challenges for EU countries. NECPs that were submitted by all Member states to the European Commission in early 2020 are just the beginning of a sustained attempt to shift to low-carbon and resource-efficient economies. The Planned Policies and Measures of the Cypriot government can yield economic benefits to society but require strong political will to implement; measures promoting green transport are crucial in this respect. Further decarbonisation measures will be needed in the coming years, which will call for an environmentally-oriented reform of the tax system and a transformation of the country's economic growth priorities, including that of the financial sector. These challenges need not be viewed as threats; instead the country can exploit business and investment opportunities arising from the energy transition of the global economy in order to adopt a new sustainable economic development model.

In the period since the submission of the NECP, the global coronavirus pandemic seems to be changing the economic and energy outlook of all European countries. The economic downturn, which at the time of this writing is expected to reach at least 10% of annual GDP levels, could adversely affect climate change policies, as governments put emphasis on expenditures related to public health and to the support of businesses and workers hit hardest by the crisis, and because the economic recession leads to lower oil prices, which renders zero- or low-carbon investments financially less attractive. However, the significant drop in low-carbon technologies in recent years, the declaration of EU leaders in March 2020 to endorse an economic recovery plan that will promote the green transition, and the statements of top European Commission officials reaffirming the commitment to the global climate agenda,

indicate that the broad EU policy priorities will not change. Therefore, the policy recommendations of this article continue to be relevant for Cyprus in its objective to attain medium and long term energy and climate goals.

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