Deliverable 6 of Service Contract No. SRSS/C2018/070:

Overall Comparison of Policies and Measures and Recommendations Regarding the National Energy and Climate Plan of Cyprus

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Abbreviations

CH_4	Methane
CO_2	Carbon Dioxide
CO_{2eq}	Carbon Dioxide equivalent
CUT	Cyprus University of Technology
CyI	The Cyprus Institute
DLI	Department of Labour Inspection
ESR	EU Effort Sharing Regulation (EU) 2018/842
ETS	EU Emissions Trading System
GHG	Greenhouse gases
ktoe	Thousand tonnes of oil equivalent
LULUCF	Land Use, Land Use Change and Forestry
MARDE	Ministry of Agriculture, Rural Development and Environment of Cyprus
MECI	Ministry of Energy, Commerce and Industry of Cyprus
MOF	Ministry of Finance of Cyprus
MTCW	Ministry of Transport, Communications and Works of Cyprus
N_2O	Nitrous Oxide
NECP	National Energy and Climate Plan
NOx	Nitrogen Oxides
OSeMOSYS	Open Source Energy Modelling System
PaMs	Policies and Measures
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter with an effective diameter up to 2.5 microns (μm)
PM_{10}	Particulate Matter with an effective diameter up to 10 microns (μm)
PPM	Scenario with Planned Policies and Measures
SO_2	Sulphur Dioxide
SRSS	European Commission's Structural Reform Support Service
UCy	University of Cyprus
WEM	Scenario with Existing Measures

1 Introduction

This report is developed within a technical support project funded by the European Union via the Structural Reform Support Programme and implemented by consortium led by the Cyprus University of Technology, in cooperation with the European Commission's Structural Reform Support Service (SRSS) under Service Contract SRSS/C2018/070.

According to Task 4 of the Tender Specifications of the Service Contract on the "Impact assessment of the Cyprus Integrated National Energy and Climate Plan", the project team has to carry out a comparison of the policy options included in the two scenarios of the National Energy and Climate Plan of Cyprus, and a summary analysis covering the key elements of the impact assessment presented in Deliverable 5 of this project. This Deliverable 6 reports on the outcome of work under this Task. More specifically, Section 2 of this report compares the policy options in terms of costs and benefits to the Cypriot society and cost-effectiveness. Section 3 provides the conclusions of the impact assessment study and main policy recommendations regarding the compliance of the Republic of Cyprus with its commitments within the framework of the Energy Union. An outlook towards deep decarbonisation by the mid-21st century is also provided.

2 Discussion of Policy Options

The Impact Assessment of the National Energy and Climate Plan of Cyprus, as presented in Deliverable 5 of this study, leads to some clear indications about the outlook of energy and climate policy of the country with a view to meeting the objectives foreseen in the EU Energy Governance Regulation. The following sections focus on a cost-benefit and a cost-effectiveness assessment of the policy options that seem to be available to Cyprus at this stage.

2.1 The Overall Costs and Benefits of Planned Policies and Measures

Table 1 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, construction of the electricity interconnector, measures for promoting public and non-motorised transport, measures related to motor vehicles, and policies related to energy efficiency improvements in buildings and industry.

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 the assessment shown in Section 3.4 of Deliverable 5.

It is evident 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 400 million Euros'2016 by 2030, representing 1.4% of the country's projected GDP[1] 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

[1] According to the macroeconomic assumptions used in the NECP, national GDP is projected to be 30.893 billion Euros'2016.

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.

Table 2 presents the corresponding changes in energy system costs for the sensitivity case of a PPM scenario without electricity interconnection. The net benefits in year 2030 seem to be slightly higher in this case, of the order of 500 million Euros'2016 or 1.6% of that year's GDP, because somewhat lower investments in power generation are foreseen compared to the PPM scenario with interconnection. However, this 'advantage' of the scenario without interconnector is short-lived: Over the medium and longer term, i.e. in the post-2030 period that is not shown in these tables, the lack in investments in renewable energy delays the transition of Cyprus to a low-carbon path. In any case, both variants of the PPM scenario show that they are clearly preferable from a societal cost-benefit viewpoint compared to the WEM scenario.

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 1, it is evident that the PPM scenario leads to lower energy system costs even without the reductions in investments of private transport. 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 European Commission's in-depth analysis of the carbon neutrality objective,[2] the World Bank[3] or other organisations.[4]

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 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.

[2] European Commission, "In-Depth Analysis in Support of the Commission Communication COM(2018) 773 - A Clean Planet for all", Brussels, 28 November 2018.

[3] World Bank (2014), *Climate Smart Development*. International Bank for Reconstruction and Development/The World Bank and ClimateWorks Foundation, Washington, DC.

[4] Coalition for Urban Transitions (2019), Climate Emergency, Urban Opportunity. Washington, DC.

Table 1 – Projected change in energy system costs in Cyprus according to the PPM scenario 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	36	15	12	13	38	54	80
	Operation & Maintenance	-2	-6	-7	-29	-34	-26	-30	-42	-53	-62
	Total	**61**	**77**	**57**	**7**	**-19**	**-13**	**-17**	**-4**	**1**	**17**
Electricity storage technologies (pumped hydro & batteries)	Investment	0	0	0	0	-3	-3	-3	-3	-3	-4
	Operation & Maintenance	0	0	0	0	0	0	0	0	0	-1
	Total	**0**	**0**	**0**	**0**	**-3**	**-3**	**-3**	**-3**	**-3**	**-5**
Electricity interconnector	Investment	0	0	0	16	16	16	17	17	18	18
	Operation & Maintenance	0	0	0	0	0	0	0	0	0	0
	Total	**0**	**0**	**0**	**16**	**16**	**16**	**17**	**17**	**18**	**18**
Sustainable mobility (buses & tram, cycle lanes, bus lanes etc)	Investment	29	50	71	92	113	135	156	215	236	250
	Operation & Maintenance	2	4	6	8	10	12	14	16	18	20
	Total	**31**	**54**	**77**	**100**	**124**	**147**	**170**	**231**	**254**	**270**
Private transport (shift to sustainable transport modes, more efficient cars, electric cars, biofuels etc.)	Investment	-43	-84	-127	-167	-207	-244	-254	-301	-344	-384
	Operation & Maintenance	-33	-66	-100	-134	-169	-204	-268	-290	-324	-382
	Total	**-76**	**-150**	**-227**	**-301**	**-375**	**-448**	**-522**	**-592**	**-667**	**-766**
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	121	120	80	49	8	-11	1	38	34	31
	Operation & Maintenance	-36	-74	-109	-166	-208	-238	-310	-347	-392	-458
	Total	**84**	**46**	**-29**	**-116**	**-201**	**-249**	**-308**	**-308**	**-358**	**-427**
Difference in Environmental Costs		**-3**	**-5**	**-7**	**-9**	**-11**	**-12**	**-14**	**-15**	**-16**	**-17**
Difference in Total System Costs Including Environmental Costs		**82**	**41**	**-35**	**-125**	**-212**	**-261**	**-322**	**-323**	**-374**	**-445**

Table 2 – Projected change in energy system costs in Cyprus according to the PPM scenario without interconnector 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**
Electricity interconnector	Investment	0	0	0	0	0	0	0	0	0	0
	Operation & Maintenance	0	0	0	0	0	0	0	0	0	0
	Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
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**

2.2 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 in Table 23 of Deliverable 5, even their full deployment is not sufficient to make Cyprus comply with the legally binding target of the Effort Sharing Regulation, i.e. to reduce its non-ETS emissions by 24% in 2030. 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 results of a previous Technical Assistance study that was conducted for the government of Cyprus, which was also funded by the European Commission's Structural Reform Support Service and has undergone peer review in an academic journal[5]. Data used in that study are consistent with those used in the OSeMOSYS model and in the present report.

The study led to the construction of a baseline and several alternative marginal emission abatement cost curves for policies and measures in the Cypriot non-ETS sectors. 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;
- 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 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 GHG 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.

Obviously, the findings of that project are in line with the results reported in the previous section of this report. Therefore, the recommendations mentioned above are fully relevant for this study as well.

That study dealt with non-ETS sectors only. As regards the justification of ETS-related measures that are included in the PPM scenario of this Impact Assessment study, i.e. those related to power generation, electricity storage and interconnection, it should be noted that their cost-effectiveness is

[5] Sotiriou C., Michopoulos A. and Zachariadis T., On the cost-effectiveness of national economy-wide greenhouse gas emissions abatement measures. *Energy Policy* 128 (2019) 519–529.

clear if one calculates from Table 1 the cumulative costs of these three measures for the entire period 2021-2030. They amount to -194 million Euros'2016, which means they are beneficial to society; and at the same time they are necessary for reaching the ETS emission reduction target and the renewables penetration target as shown in Table 23 of Deliverable 5.

2.3 Cost-effectiveness of other measures

The measures that are described in the previous section relate to energy use, agriculture and waste. Apart from these measures, additional options are included in the PPM Scenario, namely a) the proper recovery of fluorinated gases in industrial equipment and b) afforestation. This section comments on the cost-effectiveness of these two measures, based on information available to the project team which was provided by governmental authorities in August and September 2019.[6]

- As regards fluorinated gases, a legislative obligation is under preparation, which will apply to new installations and new amounts of gases to be used in existing installations. For gases that are currently in use, which have not been regulated up to now, a financial support scheme has been prepared by MARDE in order to facilitate their proper recovery. The scheme has been designed in such a way that it leads to emission reductions which correspond to avoided costs (for purchasing additional emission allowances due to non-compliance with the ESR target) that are higher than the cost of the scheme. In other words, benefits of emission reductions outweigh the costs. This has been estimated assuming gradually increasing emission allowance prices, which overall lie around 30-35 Euros per tonne of CO_{2eq}. Therefore, one can safely state that fluorinated gas recovery passes the cost-effectiveness test and is worth pursuing.

- As far as afforestation is concerned (the main LULUCF-related measure that seems to be relevant for Cyprus), MARDE announced in September 2019 plans to proceed with planting of trees around Cyprus. Starting from around 70,000 trees in 2020, it is planned to reach 300,000 trees planted per year in 2030. Moreover, MTCW prepared a proposal for planting of trees around urban and inter-urban roads of Cyprus. According to MCTW, up to one million trees can be planted next to roads by 2030. MARDE's proposal does not include a cost assessment. MCTW's proposal estimates a cost of 72 million Euros for creation of the infrastructure for the one million trees (not including watering and maintenance costs). As regards the emission reductions due to absorption of CO_2, MCTW estimates a capture of about 2.5 kt CO_2 per year by 2030, starting from very low levels and increasing gradually as trees grow. If one assumes a total absorption of 10 kt throughout the period 2020-2030, to account for the gradually increasing number of trees planted, at a cost of 72 M€ (plus watering and maintenance), this action leads to a very high cost per tonne of CO_2 abated. This clearly does not pass the cost-effectiveness test. However, if one keeps in mind that trees have a very long lifetime and will absorb higher amounts of CO_2 when they grow further, this measure can be considered as important (and maybe cost-effective) in the longer term. Still, for achieving the 2030 non-ETS emission target, it seems to be an option with low potential and large uncertainty about its feasibility.

Keeping in mind the above information, Table 3 provides a summary of the cost-effectiveness assessments mentioned in the last two Sections. It describes the contribution of all major non-ETS sectors to emissions covered by the Effort Sharing Regulation in year 2017, based on the latest data of the National Inventory Report of greenhouse gases submitted by the Republic of Cyprus. It also displays the evolution of emissions of these sectors between 2017 and 2030. The fifth and sixth column present the estimated investment costs and total net costs (from investment, operation and

[6] By the time of writing this deliverable (early December 2019) this information was not available in the form of published reports; it is expected that the relevant data will be included in the final NECP of Cyprus.

maintenance) for the entire period 2020-2030 by sector, on the basis of the assessments made in our study; such costs are not provided for the policies and measures related to waste management, agriculture and recovery of fluorinated gases, as it has not been possible to collect or reliably estimate costs for the relevant measures foreseen by national authorities. It should be underlined that, even of this cost information were available, it would not be appropriate to calculate a cost-effectiveness index on the basis of costs and emission abatement during the decade 2020-2030 only. Most of these measures have a much longer lifetime and will hence continue to yield emission benefits over a period much beyond 2030. The proper way to compare cost-effectiveness of measures with different lifetimes is to calculate the annualised discounted costs and the corresponding emission abatement of each investment.

This is done in the eighth and ninth column of Table 3, which provide summary information on costs per tonne of CO_{2eq} abated for each sector, based on the results of the study of Sotiriou et al. mentioned in footnote 5. The last column shows assessments made with the aid of information provided by governmental authorities on the management of fluorinated gases and afforestation – measures that had not been considered by Sotiriou et al.

The overall conclusion that can be drawn from Table 3 is 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[7]. 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 costly over the short and medium term, but if one takes into account that trees have a very long lifetime and can therefore reduce carbon emissions for many decades, it turns out to be a beneficial measure; it has to be noted, however, that the costs of afforestation may have been underestimated because cost estimates do not include water and maintenance costs, which may be particularly important for trees planted around the road network.

[7] IWG (Interagency Working Group on Social Cost of Carbon), 2013. Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866. United States Government, revised November 2013.

Table 3 – Summary of emissions, costs and cost-effectiveness estimates for the major non-ETS sectors of Cyprus.

Sectors	% of non-ETS Emissions in 2017 (national emissions inventory data)	Emissions 2017 (kt CO_{2eq})	Emissions 2030 in PPM Scenario (kt CO_{2eq})	Investment Cost 2020-2030 (mio Euros'2016)	Net Cost 2020-2030 (mio Euros'2016)	Cost-effectiveness (Euros'2016 per tonne of CO_{2eq} abated)*	Cost-effectiveness (Euros'2016 per tonne of CO_{2eq} abated), including reduced damages from air pollution improvement*	Other cost-effectiveness assessments
Road Transport - public measures				1378	1509			
Road Transport - private measures				-2067	-4776			
Total Road Transport	49%	2093	1681	-689	-3267	Ranging between 59-95 €/tn: 59 (electrification of cars); 69 (promotion of public transport; 95 (CNG fuelled trucks)	-2 €/tn (electrification of cars and promotion of public transport); -100 €/tn (CNG fuelled trucks)	
Energy Use in Buildings and in Non-ETS Industry	19%	715	701	782	644	Ranging from -500 €/tn for roof insulation and heat pumps to >1000 €/tn for wall insulation & deep renovations of old buildings; most policies and measures in this sector have negative costs and should be adopted		
Agriculture (including livestock waste)	12%	495	512	not available	not available	4 €/tn	-41 €/tn	
F-Gases	6%	250	268	not available	not available	not considered in that study		-7,5***
Waste Management - solid & liquid waste	14%	514	305	not available	not available	not considered in that study		not available
LULUCF**		-534	-635	72	100	not considered in that study		> 500****

* Source: Sotiriou, Michopoulos & Zachariadis, *Energy Policy* 128 (2019) 519–529
** Calculations of MARDE based on data from Forestry Department
*** Information from MARDE for the period 2020-22: 1.5 mio Euros in avoided allowance purchases; 1.125 mio Euros cost of measure; 50 kt CO_{2eq} abated
**** estimated cost If one considers a 30-year period; much lower if one assumes that CO_2 absorption will continue to the distant future

2.4 Multi-criteria assessment of the two scenarios and the sensitivity case

Based on the main results of the impact assessment that were presented in Deliverable 5, and on the cost-benefit and cost-effectiveness appraisals reported in the previous sections of this Deliverable, it is possible to compare the WEM and PPM scenarios of the Cypriot NECP on the basis of a set of criteria. This section provides a brief multi-criteria evaluation of the two scenarios.

1. **Energy and environmental criteria**: The Planned Policies and Measures Scenario is clearly the preferred scenario with regard to all energy and environmental criteria included in the energy Union strategy. It can lead to:

    - Lower GHG emissions (14% lower in 2030 compared to 2005, as opposed to only 3% emission reductions in the WEM scenario);
    - Improved energy efficiency, which can lead to compliance with the requirements of Article 7 of the Energy Efficiency Directive, as opposed to non-compliance in the WEM scenario;
    - Improved penetration of renewable energy sources, reaching 30% of total energy consumption in 2030 and leading to compliance with the corresponding EU-wide objective, as opposed to 20.7% in the WEM scenario which is not sufficient to meet the EU-wide commitment;
    - Achievement of the EU objective for reaching 14% share of renewable energy in transport by 2030, as opposed to just 7% in the WEM scenario;
    - Improvement in air quality thanks to a reduction in emissions of air pollutants NOx, PM and SO_2 of 4.3%, 6.8% and 38.5% respectively in 2030 compared to the WEM scenario, leading to fewer public health problems in the population of Cyprus, to a decrease in premature pollution-related deaths and to a reduction in health-related economic damages of 23.5 million Euros'2016.

Thus the PPM scenario is the one that can enable Cyprus to contribute to the EU's objective to comply with its international climate obligations deriving from the Paris Agreement. It is also preferred in comparison to the PPM scenario without electricity interconnection: although the latter may display slightly lower non-ETS emissions in 2030, these emissions are projected to increase after 2030; therefore a scenario without interconnection fails to bring Cyprus on track with the EU long-term decarbonisation strategy.

2. **Economic criteria**: The Planned Policies and Measures Scenario is also the preferred scenario with regard to the economic criteria considered in this study. More specifically, it can result in:

    - A small increase in national GDP by the year 2030, of the order of 0.4% compared to the WEM scenario; this will be a result of the re-allocation of investments in the PPM scenario and the re-adjustment of economic output towards activities with higher local value added, coupled with a decline in costs for importing fossil fuels thanks to the substantial decrease in fossil fuel consumption compared to the WEM scenario;
    - An overall benefit to society that can reach 594 million Euros'2016 in 2030 (or 2% of that year's GDP) compared to the WEM scenario; this benefit will be a combination of reduced energy system costs (thanks to energy savings in buildings, industry and primarily in road transport) and reduced health-related economic damages.

3. **Social criteria**: The Planned Policies and Measures Scenario is also estimated to yield slightly better results in employment and social welfare because:

- It is projected to lead to somewhat higher employment, about 0.4% higher in 2030 compared to the WEM scenario, which means about 2350 more full-time work positions; this will be a result of the re-structuring of the economy towards jobs in economic sectors that benefit from the increased promotion of energy efficiency and renewable energy.
- It is expected to have an essentially zero effect on social equity, i.e. negligible effects on the distribution of income between households of different income groups; this will be the composite result of changes in electricity and fuel prices between the WEM and PM scenarios as explained in Section 3.2 of Deliverable 5 of this study.
- Compared to a scenario without electricity interconnection, it involves larger investments especially in renewable energy and hence a higher positive effect on GDP and employment.

4. **Governance criteria**: In terms of administrative costs, simplification of planning, reporting and monitoring obligations, and ensuring a coordinated and coherent implementation of the Energy Union strategy across its five dimensions, the PPM scenario is not expected to add considerable administrative burden compared to the WEM scenario; conversely, because the PPM scenario is clearly superior to the WEM scenario in all other criteria mentioned above, it will certainly contribute to a better implementation of the Energy Union strategy across its five dimensions.

3 Conclusions and Policy Recommendations

Deliverable 5 presented the results of the Impact Assessment study of the National Energy and Climate Plan of Cyprus. 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 that has been used for the assessment of national energy efficiency action plans of Cyprus in the recent past, which were then input to OSeMOSYS. The optimisation results, as shown in Chapter 2 of Deliverable 5, along with the associated costs and calculated emissions of GHGs and air pollutants, have been fed into other models in order to assess the macroeconomic and employment impacts of the two scenarios that were explored. Apart from the above energy-related data and results, information about emissions abatement and costs for non-energy-related GHG emissions were obtained from the relevant calculations of national authorities that are included in the NECP of Cyprus.

Taking into account that national authorities have decided to proceed in their energy and climate policy in three stages (Stage 1 being in line with the WEM scenario, Stage 2 being consistent with the PPM scenario and Stage 3 being an intention to proceed with more ambitious measures in the near future), the main findings presented in the Impact Assessment report, some of which are illustrated in Figure 1, can be summarised as follows:

1. **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 they can only lead to 3% reduction in non-ETS emissions in 2030 compared to 2005; this will require purchasing a significant amount of emission allowances to fill the 2030 emissions gap, which, under optimistic assumptions, will cost the Republic of Cyprus at least 131 million Euros[8] in the period up to 2030. Moreover, non-compliance with the 2030 target of 14% renewable energy in transport will lead to additional costs in the WEM scenario, because the gap in renewable share will have to be covered through the Statistical Transfer procedure.

2. **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, **is able to make Cyprus meet its goals regarding energy efficiency and penetration of renewable energy sources**. If fully implemented, these measures will lead to **net economic benefits to the society of more than 500 million Euros'2016** by 2030, accompanied by **small positive effects on economic indicators** – a 0.4% increase in national GDP and a 0.4% rise in total employment in 2030. The changes in energy costs to end consumers will be very small and overall will have essentially no adverse impact on the welfare of households and social equity.

3. **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

[8] This calculation is based on assumptions provided by MARDE about the evolution of ETS allowance prices up to 2030. They are considered to be optimistic because Cyprus will not have the right to 'borrow' emission allowances from ETS installations, and since most EU Member states expect to be in deficit of allowances for meeting their 2030 ESR targets, it is likely that the cost for purchasing allowances to cover the non-ETS emissions gap will be considerably higher.

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 2 billion Euros'2016. Coupled with a fast electrification of the passenger car sector, they seem to be the only way to achieve the 2030 non-ETS emission reduction target and shift the whole Cypriot economy to a low-carbon path towards 2050.

4. **The required additional investments to realise the PPM scenario (189 million Euros) are entirely feasible** for the standards of the Cypriot economy and will pay off because fuel import costs throughout the lifetime of these measures may decline considerably due to these investments.

5. 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.

6. 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.**

7. 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.

8. In the event that the project of electricity interconnection of Cyprus with Greece and Israel is not realised (sensitivity case of stage 2), penetration of renewable energy will be considerably lower. This may endanger the compliance of Cyprus with its renewable energy commitments in 2030, and will slow down investments for decarbonising the electricity system.

9. **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.

10. **Even if implemented fast and effectively, stage 2 (Planned Policies and Measures) is not sufficient for reaching the non-ETS GHG emission reduction target of 24% by 2030**, as required from Cyprus in the Effort Sharing Regulation; the reduction can only reach 14% in the PPM scenario. In order to achieve full compliance, the government of Cyprus has to choose between three options:

    a. Not proceed with further GHG emission abatement measures and use instead flexibility mechanisms to purchase emission allowances, with the associated costs; these are estimated to reach at least 55 million Euros up to 2030 but as indicated in point 1 above, may reach much higher levels if several EU Member States are in need to purchase emission allowances to fill their own emission abatement gap.

b. 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 costly and extremely difficult to implement at such a scale within the short time frame available; therefore they cannot be considered as a realistic alternative.

c. Induce energy conservation measures 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[9].

11. 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.[10,11,12] Therefore, **purchasing allowances to fill the 2030 emissions gap is both costly and does not lead to a strong decarbonisation path towards 2050**; instead it locks the Cypriot economy to an unsustainable path.

12. 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 non-ETS emission reduction target of 2030 and for enabling the transition to a net-zero-carbon economy by 2050**.

[9] Zachariadis T., A Proposed Green Tax Reform for Cyprus and its Co-Benefits for Urban Sustainability In: *Critical Issues in Environmental Taxation*, Ezcurra M.V., Milne J., Ashiabor H. and Andersen M.S. (Eds.), Edward Elgar, 2019.

[10] Zachariadis T., Michopoulos A., Vougiouklakis Y., Piripitsi K., Ellinopoulos C. and Struss B., Determination of Cost-Effective Energy Efficiency Measures in Buildings with the Aid of Multiple Indices. *Energies* 11 (2018), 191; doi:10.3390/en11010191

[11] Sotiriou C. and Zachariadis T., Optimal Timing of Greenhouse Gas Emissions Abatement in Europe. *Energies* 12 (2019), 1872; doi:10.3390/en12101872.

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Figure 1 – Overview of the findings of the Impact Assessment study as regards compliance with the national non-ETS emissions target of Cyprus.