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A Critical Review of the Updated 2023 Greek NECP

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Summary

In this note, a comparison of the Greek NECP submitted to the European Commission (EC) in November 2019 that had taken into account the EC recommendations and the updated NECP presented on 16 January 2023 that is in line with the new enhanced European Union (EU) targets including the 55% GHG emission reduction by 2030, the Climate Laws of the EU and Greece and the legislation enacted to meet these targets. The comparison has been extended to include the net-zero by 2050 scenarios of the Greek Long-Term Strategy Roadmap to 2050 announced in December 2019 as the upgraded NECP, unlike the 2019 one, provides core information till 2050.

Unfortunately, the information released was in a deck of 28 PPT slides without an accompanying text to flesh out basic strategic considerations and appropriate policies and measures, economic consequences and sources for the very high investments needed and certainly not in the depth and structure of the recently approved NECP template. In short, its presentation was rushed, perhaps by considerations of political advantage in light of the uncertainty of the date for the upcoming elections that have to take place by end of June 2023 which though casts doubt on the political robustness of the updated draft NECP.

Three scenarios seem to have been examined ranging from very high utilization of RES (scenario A) to very high emphasis on energy efficiency (scenario B). The one proposed is the intermediate one A/B. For both of the other two the information provided is even more scant making an assessment of whether the proposed A/B stands vis-a-vie the other two.

In the time horizon of primary interest till 2030, the updated NECP, is seen to be much more ambitious than the 2019 version in the main key indices, namely:

- The GHG emission reduction is now 55% wrt 1990 vs. 40%
- The non-ETS sector emissions reduction is 47% wrt 2005 vs. 40%
- The RES contribution to GFEC is 45% vs. 35%
- The FEC is 15.3Mtoe vs. 16.5Mtoe
- The RES share of electricity production is 80% vs. 61%
- Investment increases to €27.04Billion/yr on average for the 2020-2030 period vs €18.39Billion/yr

In the electricity sector, the decommissioning of all lignite units by 2028 is re-affirmed and a large deployment of offshore wind, pumped storage and battery use is envisioned by 2030 (2.7GW, 2.5GW and 5.6GW respectively). Furthermore by 2030 the upgraded NECP also calls for 200kt of H_2 and 200ktoe of synthetic fuel production. Such deployment needs robust documentation of their realizability which is not provided. NG generation is almost halved from 22TWh in 2021 to 12TWh.

In the longer term to 2050, the tendency to install voluminous amounts of RES continues reaching 69.7GW by 2050 (from ca 14GW currently) and generating 162.6TWh (from 50.5TWh in 2030) with its production going to cover electrification of all sectors, but also production of H_2 (2.3Mt) and synfuels (2.8Mtoe).

The upgraded NECP does meet the 2040 targets of 80% reduction of GHG emissions wrt 1990.

The proposed A/B scenario of the upgraded NECP seems to stay close and in some case to go beyond the NC1.5 scenario of the Long-term Strategy Greek Roadmap to 2050 which also calls for high-RES utilization (63.8GW) as opposed to the EE1.5 scenario which is based on large increase of energy efficiency and only 33.6GW of RES. In the Residential/Tertiary sectors reductions come mostly from renovation and improvement

of appliance efficiency but are counterbalanced somewhat by the large increases of the number of appliances. The turn to technological advances rather than to demand side management is also the case in Transport where passenger-kilometers and ton-kilometers increase. This is the main drawback of this draft of the upgraded NECP as released, namely that it does not utilize enough demand side management and the possibilities of sufficiency and behavior change not only of consumers but also industry practices.

It would be remiss to close without restating the inadequacy and hastely conceived compilation of the format and information made public, and the unreasonable procedure for its release that leaves the process in limbo.

The 2023 Greek NECP

On 19 November 2019, after a short public consultation, and following the EC recommendations on the initial NECP (C[2019]4408 final) first submitted in January 2019, the Greek Government submitted its final NECP[1] to the European Commission. That NECP (henceforth NECP19) included a 35% contribution of RES on gross final energy consumption (GFEC), a reduction of GHG emissions by 42% with respect to (wrt) to 1990, and a final energy consumption (FEC) of 16.3Mtoe by 2030, and a very ambitious schedule for decommissioning of all lignite plants by 2028.

In view of the new, much more ambitious target of 55% GHG emission reduction wrt to 1990 that has been adopted by the European Union and the passage of its Climate Law, and pursuant to Art 14 of Regulation (EU) 2018/1999, for the period 2021-2030, Member States are to submit draft updated integrated NECPs by 30 June 2023 and final ones by 30 June 2024 following guidance provided in Regulation (EU) 2022/2299..

Furthermore, in May 2022, Greece adopted its own Climate Law (L4938/2022) which calls in Art 1 for a 55% GHG emissions reduction by 2030 wrt 1990, an 80% reduction by 2040, and net zero emissions by 2050. It also calls for the establishment of 5-year sectoral emission targets (Art 8) with the first ones to be adopted in 2024 to cover the 2026-2030 period.

On 16 January 2023, the Minister for Environment and Energy made public[2] a draft version of the updated NECP (henceforth NECP23) in the form of a 26 slide Power Point presentation but without any accompanying report providing rationale and details. From unofficial sources an additional 22 slide PPT presentation with information broken down by sector has been obtained. Ministry sources have stated that it is the current Government's ambition to be among the first MSs to submit a final version of the NECP23 to the European Commission (EC). This does not seem to have many chances of taking place in view of the upcoming national elections which have to take place by 7 July 2023 with the most likely date being the 10th of April.

1. Overview of the 2023 Greek NECP

In compiling the new NECP23 apparently three scenarios A, B and A/B have been examined. Scenario A is oriented to very large RES installation and production and less so on energy efficiency, Scenario B with large emphasis on energy conservation and less so on RES production and a composite one A/B somewhere between the two. As the major portion of the information made public refers to the A/B scenario, it is assumed that this is the one that will be put forward eventually for public consultation and submission to the European Commission (EC).

Focusing on the period 2020-2030 for which more details are provided the major features of NECP23 are:

1. Th GHG emissions are estimated to be reduced by 55% wrt 1990 as called for in the Greek Climate Law. Also, the emission reduction is projected to reach 82% by 2040 (18.9 $MtCO_2$ compared to 107 $MtCO_2$ in 1990) slightly higher than the 80% called for in the Greek Climate Law. In 2050 the total emissions amount to 9.1 $MtCO_2$ of which 7 $MtCO_2$ are coming from the non-CO_2 emissions (CH_4, N_2O and F-gases). This would require an equal number of sinks to reach carbon neutrality.

[1] https://energy.ec.europa.eu/system/files/2020-03/el_final_necp_main_en_0.pdf
[2] https://ypen.gov.gr/kostas-skrekas-me-to-neo-proteinomeno-esek-dinoume-yperaxia-stin-elliniki-oikonomia-dimiourgoume-nees-theseis-apascholisis-kai-epitygchanoume-antagonistikes-times-energeias/

2. The non-ETS emissions (ESR) are to be reduced 47% wrt 2005 by 2030, much higher than the legally binding assigned target of 22.7%.
3. A re-affirmation of the complete delignitization by the end of 2028 but without any specific schedule for the currently operating units which in previous Government and Public Power Corporation (the owner and operator) were to be decommissioned much earlier and possibly as early as 2025. Under NECP23, 4 units totalling 1.5GW (out of a total of 2.6GW in early 2023) will still be operating in 2025, of which 3 will be decommissioned sometime by 2028, with the fourth, Ptolemais V which went into trial operation in December 2022 scheduled to operate till end of 2028.
4. The RES installed capacity is to increase from 13,1GW (including 3.2GW Hydro) in 2022 to 28.3GW by 2030. This increase is mostly in PV (9.3GW) and wind (4.8GW) installations, resulting in a 45% contribution to Gross Final Energy Consumption (GFEC) and 80% in electricity production by 2030.
5. The Final Energy Consumption (FEC) to reach 15.3Mtoe (16.68Mtoe GFEC) in 2030, from 20.22Mtoe in 2005 and 14.95Mtoe in 2021 according to the Energy Balance of Greece (2023 edition).
6. It also calls for the production of 205kt of green H_2 and 185ktoe of synfuels by 2030.

The NECP23 is clearly more ambitious compared to the 2019 version of the NECP (henceforth NECP19). In particular, for the near-term period to 2030:

- The GHG emission reduction is now 55% wrt 1990 vs. 40%
- The non-ETS sector emissions reduction is 47% wrt 2005 vs. 40%
- The RES contribution to GFEC is 45% vs. 35%
- The FEC is 15.3Mtoe vs. 16.5Mtoe
- The RES share of electricity production is 80% vs. 61%
- Investment increases to €27.04Billion/yr vs €18,39Billion/yr

In the next section, a more detailed presentation of NECP23 and its comparison to NECP19 is provided. As energy scenarios and their modelling do not stop in 2030, the comparison will also cover the period past 2030 to 2050 making use of all information available.

2. The longer road to 2050

The NECP23, unlike the NECP19, includes some information (in tabular terms) extending to 2050. This provides a basis for comparison with the Greek LTS Roadmap2050[3] (henceforth LTS2050) net zero scenarios which were also carried out utilizing the PRIMES suite of models.

The Greek LTS2050 was submitted to the EC in January 2019. It utilized the PRIMES model to examine 6 scenarios that consider the achievement of the NECP19 objectives by 2030 as a given and assume full implementation of the NECP19 policy priorities and measures and do not include additional measures. Of the six scenarios considered, only the so-called EE1.5 (Energy efficiency and Electrification, i.e., replacement of fossil fuels by electricity, conservation and circular economy) and NC1.5 (New energy Carriers, i.e., extended use of H_2, biogas, synthetic CH_4 and also conservation etc) achieve near net zero emissions by 2050 and are in line with the 1.5°C Paris Agreement target. Here, only these two scenarios will be considered and compared.

[3] https://ec.europa.eu/clima/sites/lts/lts_gr_el.pdf. As it is available only in Greek, a detailed presentation and analysis is provided in https://facets.gr/wp-content/uploads/2023/02/Overview-Greek-NECP-LTS-FACETS-2020.pdf

2.1 The general exogenous parameters inputted

In view of the longer horizon, it is first important to look at the trajectories of basic exogenous data that have been inputted into the modelling for which the PRIMES suite of models has been utilized (unlike the previous 2019 version for which the TIMES-MARKAL was mostly utilized). The PRIMES model was also utilized for the LTS2050 which also included projections for 2030. In Table 1, the trajectories of GDP, Demographics, fuel and ETS emission allowance prices are shown for NECP23 and NECP19. The corresponding values for the LTS Roadmap2050 for Greece as submitted in 2019 are also included for comparison purposes.

Table 1: General Input parameters

	2015	2020	2025	2030	2035	2040	2045	2050
GDP								
NECP-2023 (Market values)		168.2	194.8	200.4	212.4	231.2	251.2	272.1
NECP-2019 (Million €2010)	184.0	200.0	221.7	244.7				
LTS2050 (Market values)				226	249	275	303	326
Demographics								
Population (1000)								
NECP-2023		10.697	10.510	10.303	10.105	9.911	9.714	9.505
NECP-2019	10.858	10.691	10.538	10.368				
LTS2050				10.392	10.225	10.046	9.861	9.663
Number of Households (1000)								
NECP-2023	4.373	4.382	4.371	4.336	4.313	4.294	4.285	4.274
NECP-2019	4.120	4.076	4.081	4.107				
LTS2050								
Fuel Prices								
Crude Oil								
NECP-2023 (€2015/GJ)	29.00	22.00	51.00	54.00	51.00	54.00	59.00	66.00
NECP-2019 [€2016/GJ]		11.90	15.73	17.33				
LTS2050		9.70		14.33	15.41	16.36	16.84	17.13
Natural Gas								
NECP-2023 (€2015/GJ)	24.00	11.00	44.00	38.00	38.00	38.00	38	40
NECP-2019 (with transport cost)		6.8 (7.8)	7.71 (8.7)	8.12 (9.1)				
LTS2050		6.16		7.57	7.88	8.36	8.84	9.08
Coal								
NECP-2023 (€2015/GJ)	7.00	5.00	10.00	10.00	10.00	11.00	12	12
NECP-2019 [€2016/GJ]		3.31	4.37	4.81				
LTS2050		2.15		2.68	2.87	2.99	3.10	3.27
ETS allowance prices [€2016/tCO2]								
NECP-2023	7.50	25.00	80.00	80.00	110.00	235.00	340	390
NECP-2019		24.00	28.77	31.23				
LTS2050				31.20	64.00	127.50	183	380

A number of differences are seen in some parameters, most notably in the NG and crude oil prices in NECP23 that now incorporate the upheavals of the last 2 years. A second large difference is seen in the ETS allowance prices that in the NECP23 show a sharp increase earlier by 2030 compared to those of NECP19, and with the NECP23 ones ending up at the same level by 2050 with those of LTS2050.

Finally, the GDP growth rates in NECP23 are lower (between 0.6% in 2030, increasing in the 2040-2050 period to ca 1.7% vs. 1.9% in 2030 and 1.8% for the full 2030-2050 period of LTS2050. The population trend in NECP23 is negative and similar to that of LTS2050.

2.2 Emissions trajectories

The overall emissions trajectories for NECP23, NECP19 and LTS2050 are given in Table 2a.

Table 2a: GHG emissions								
	NECP-2019 and NECP-2023						EE1.5	NC1.5
	2015	2020	2025	2030	2035	2040	2050	
Total GHG Emissions (Mt CO_2eq)								
NECP-2023	96,4	71,3	70,9	49,2	34,5	18,9	9,1	
NECP-2019		82	69	61	58	55		
LTS2050			69,5	57,1			5,7	5
GHG Reduction wrt 1990 (103.3MtCO_2)								
NECP-2023	10,3%	33,7%	34,0%	54,2%	67,9%	82,4%	91,5%	
NECP-2019		23,7%	35,8%	43,3%	46,0%	46,8%		
LTS2050				44,6%			94,5%	95,2%

The total **GHG emissions** in NECP23 are clearly lower than in NECP19. In 2030 though, they are slightly below the 55% overall EU target. The 54.2% figure is based on the actual 1990 GHG emissions total of 107.5MtCO_2. which includes the penalty imposed on Greece due to omissions in its inventory system identified by the in-country visit of the UNFCCC Secretariat Team in 2007. If the emission value of 103.3MtCO_2 inscribed in the Greek Inventory as submitted to UNFCCC annually, the reduction is lowered to 52%. In either case, in 2040 the reduction is higher than the 80% inscribed in the Greek Climate Law (Art1). The NECP23 emissions (not counting LULUCF sinks) are seen to be almost double those of the LTS2050 scenarios.

NECP23, unlike NECP19, calls for a large drop of emissions in the 2030-2040 decade. While NECP19 did not include emission projections to 2050, NECP23 includes a value of 9.1MtCO_2 of which 7MtCO_2 are non-CO2 emissions most likely resulting from the agricultural sector plus a small amount of F-gas from aluminium production. To reach net zero then would require an equivalent number of sinks from LULUCF or additional amounts of Direct Air Capture (DAC) and Storage (CCS). No information is provided regarding CCS and DAC or LULUCF sinks in NECP23 in contrast with the LTS2050 where the two net zero scenarios EE1.4 and NC1.5 call for 6.7 MtCO_2 and 18.4 MtCO_2 from CCS and DAC respectively.

Turning to a break-down by sector, the respective emissions are provided in Table 2b (differences in totals between Tables 2a and 2b are not typographical errors in this report). In Table 2b, emissions in the Industrial Sector are the sum of direct Industrial Sector emissions plus the non-energy related CO2 emissions as inscribed in NECP23 which are taken to be the process emissions from industry.

In the 2020-2030 decade, in view of the COVID-19 disruption, only the second half 2026-2030 might be comparable. Thus, in the 2026-2030 period, the energy sector reduction rate difference is notable which is the result of increased RES production and decreased use of NG for electricity generation. The large NECP23 acceleration of emission reductions (compared to NECP19) in the 2030-2040 period is seen to come from a three-fold emission reduction (ca 70%) in all sectors and a two-fold one in non-CO2 emissions. This is to be compared with reductions of 20-30% for NECP19 in the same decade. The reduction rate falls to ca 50% in the 2040-2050 period as low hanging fruits have already been harvested.

Table 2b: GHG emissions by Sector								
	NECP-2019 and NECP-2023						EE1.5	NC1.5
	2015	2020	2025	2030	2035	2040	2050	
GHG Emissions by Sector (Mt CO_2)								
NECP-2023	97,0	72,3	71,9	50,2	35,1	19,1	8,9	
NECP-2019		80,9	68,7	59,9	57,7	54,8		
LTS2050				57,1			-0,3	-1,0
Energy Sector								
NECP-2023	40,2	20,9	21,3	6,5	3	0,3	-0,3	
NECP-2019		27,3	17,3	11	9,1	8,2		
LTS2050				9,6			-0,6	-0,5
Industry (with process emissions)								
NECP-2023 (with non-energy CO2)	12,1	11,7	11,4	10,9	7,6	3,3	1,7	
NECP-2019		9,9	9,4	8,8	8,7	9,0		
LTS2050				11,3			-0,1	-0,6
Residential &Teriary & Agri								
NECP-2023	7	5,6	5,2	3,4	1,7	0,9	0	
NECP-2019		6,3	5	4,3	4,2	3,7		
LTS2050				3,2			0,2	0
Transport								
NECP-2023	19,2	16,1	19,2	16,5	11,5	5,9	0,5	
NECP-2019		17,4	17,5	16,5	16,1	15,3		
LTS2050				18,8			0,2	0,1
Non-CO2 emissions (CH_4, N_2O,F-gases)								
NECP-2023	18,5	18,0	14,8	12,9	11,3	8,7	7,0	
NECP-2019		20	19,5	19,3	19,6	18,6		
LTS2050				14,2			6,0	6,0

2.3 Final energy consumption

As most policies and measures (PaMs) are directed to specific sectors to affect their energy consumption, of interest is also the sectoral final energy consumption in NECP23 which is given in Table 3a.

Again, the notable differences between NECP23 and NECP19 are found in the 2030-2040 decade. The sector with the most differences is Transport, which shows the largest yearly reduction rates of 2.2% for the 5-year period 2031-2035 and a higher one of 3% for the 2036-2040 period compared with less than 0.5% for NECP19. This is in line with the timing of the fleet renewal from today's ICE vehicle majority whose life cycle is coming to an end and is replace by mostly electric ones. The resulting average yearly rate for the 2030-2050 period is 2% which is the same with that in the EE1.5 scenario of LTS2050 but higher than the 1.6% of the NC1.5 one.

In the Industrial sector the NECP23 behavior is similar with reductions taking place in the 2030-2040 period at an annual rate of 1.5% coupled with negligible reductions in the 2040-2050 period as well as in the 2025-2030 period. In contrast, NECP19 shows an almost flat trajectory from 2020 to 2040 (no data are available past that). The average yearly reduction rate for the 2030-2050 period is 0.7% which is the same as that of the NC1.5 LTS2050 scenario and almost half of that of the EE1.5 one (with 1.1%).

The Residential and Tertiary sectors show a different behavior. In the Residential sector the largest reduction rate of NECP23 is in the 2026-2030 period at 2.8% dropping to 1.8% in the next 5-year period and further down to 0.5% in the 2036-2040 period and remains at that level till 2050. The NECP19, without the hindsight of the COVID19 effect shows its maximum reduction rate earlier starting in the 2021-2025 period at 1.6% which drops down to 0.4% in the 2025-2030 period, goes back up to 0.9% and drops yet again lower to 0.25% in the last 5-year period of 2036-2040. The NECP19 report does not provide a reason for this wavy behavior. The average annual rate of NECP23 for the whole 20-year period 2030-2050 is 0.9% much closer to NC1.5 (with 1.2%) than the much higher 2.0% rate of EE1.5 with its emphasis in energy conservation.

The maximum reduction of about 1% in the Tertiary sector is delayed till the 2031-2035 period at about 1%, remains at that level in the next 5-year period and drops down to 0.4% till 2050. On the contrary, NECP19 shows an increase of ca 0.3% for the whole period till 2040. The 20-year period reduction of 0.64% is below both NC1.5 and EE1.5 (at 0.90% and 1.2% respectively) but nearer to the first (NC1.5) with its lower energy efficiency focus.

Table 3a: Final energy Consumption

(ktoe)	NECP19 and NECP23						EE1.5	NC1.5
	2016	2020	2025	2030	2035	2040	2050	
Total FEC								
NECP23	16588	14710	16531	15303	13707	12688	11469	
NECP19 (w/o bunkers & HPs)		16926	16713	16508	16227	16181		
LTS2050 (w/o bunkers)				16128			10632	12184
Industry								
NECP23	3127	2852	3162	3096	2640	2658	2669	
NECP19		3011	2943	2879	2930	2968		
LTS2050				3086			2373	2660
Residential								
NECP23	4456	4106	4210	3630	3296	3208	2999	
NECP19		4572	4211	4130	3945	3895		
LTS2050				3931			2346	3018
Tertiary & Agriculture								
NECP23	2398	1970	2273	2157	2055	1956	1881	
NECP19		2346	2396	2433	2465	2503		
LTS2050				2303	0	0	1764	1890
Transport								
NECP23	6607	5782	6886	6420	5716	4866	3920	
NECP19 (w/o bunkers)		6997	7163	7066	6887	6815		
LTS2050				6808			4149	4616

It should be noted that, albeit with different rates, all three sectors (Industry, Residential and Tertiary) by 2050 end with absolute FEC values very close to those of the NC1.5 LTS2050 scenario and much higher than those of the EE1.5 one.

Turning to the basket of fuels used to meet final demand shown, in Table 3b, the main difference between NECP23 and NECP19 is the much faster reduction in NECP23 in the use of all fossil fuels by 2030 and their replacement by H_2 and synfuels. This presupposes that the construction of the H2 and synfuel capacity will be completed in part at least in time which now seems unrealistic. Again, in the longer-term comparison to 2050, virtually all use of fossil fuels in NECP23 is eliminated. The use of new carriers (H_2 and synfuels) is much more than that of EE1.5 and close to that of NC1.5 scenario. The same is true for the direct use of RES in all sectors.

Table 3b: Final energy Consumption (by Fuel)								
(ktoe)	NECP19 and NECP23						EE1.5	NC1.5
	2015	2020	2025	2030	2035	2040	2050	
Total FEC by Fuel								
NECP-2023 (w/o Bunkers, HPs??)	16578	14710	16531	15303	13705	12688	11469	
NECP-2019 (w/o Bunkers & HPs)		16926	16713	16508	16227	16121		
LTS2050 (w/o Bunkers & HPs)				16104			10375	11868
Solid Fuels								
NECP23	211	209	243	200	90	27	3	
NECP19		160	139	153	181	188		
LTS2050				0			0	0
Oil Products								
NECP23	9411	7841	8687	7243	4643	2042	188	
NECP19		9287	8551	7750	7190	6624		
LTS2050				7247			28	32
Natural Gas								
NECP23	972	967	1077	788	616	682	8	
NECP19		1244	1597	1759	1933	2031		
LTS2050				1711	0	0	406	97
Electricity								
NECP23	4367	4135	4553	4830	5275	5650	6025	
NECP19		4612	4680	4852	5143	5383		
LTS2050				5131			6221	5854
Heat								
NECP23	50	56	86	84	195	203	222	
NECP19		43	41	39	37	35		
LTS2050				49			16	21
Hydrogen								
NECP23			0	74	248	652	1091	
NECP19			0	0				
LTS2050							116	915
Synfuels								
NECP23			0	181	658	1155	1940	
NECP19			0	0				
LTS2050							0	2689
RES (direct use)								
NECP23	1567	1502	1885	1903	1980	2277	1992	
NECP19		1580	1705	1955	1743	1860		
LTS2050				1966			3588	2260

Unfortunately, not enough information is provided to check the 45% figure of RES contribution to GFEC or to estimate its evolution. The RES and biomass direct input though to the energy branch by 2050 is listed as 20239ktoe vs. the 13006ktoe for total GFEC for a ratio of 155.6%, with respective values for 2030 of 6583ktoe and 16682ktoe for a ratio of only 39.4%.

In Residential and Tertiary sectors, the contribution of ambient energy is not included in Tables 3a and b. The NECP23 does provide information but only to 2030 and not explicitly for each sector. In Table 4 below a partial comparison with NECP19 is provided.

Table 4: Ambient energy

(ktoe)	NECP19 and NECP23						EE1.5	NC1.5
	2020	2021	2025	2030	2035	2040	2050	
NECP23 Ambient		421	708	990				
NECP19 Ambient	410		692	876	1018	1027		
Energy Balance (Tertiary/Total)	303/387	341/440						

Finally, the NECP23 includes as input to the Energy branch from zero in 2020 17ktoe of H_2 by 2025. As there is no new production facility of H_2 (beyond the existing ones in the refineries for their own use) nor is it feasible to construct one by 2025, it is not clear where this would come from (possibly imports) and where it will be utilized. By 2030, NECP calls for 55ktoe input to the energy sector, 74ktoe of FEC, 200kt H_2 (or was ktoe meant?) and 200ktoe of synfuels produced. This begs for a clearer picture of the timing, production, imports and utilization of H_2.

2.4 Electricity

Electricity plays a central role in all scenarios examined. In Table 5, the installed capacities and related generation from all means is shown. Unfortunately, NECP19 does not provide estimates beyond 2030. So, comparing the two NECPs to 2030, a substantial (20%) higher overall capacity in NECP23 is noticed which comes from increased PV installation. This seems realistic in view of the resistance of local communities to onshore wind which results in delays of construction. Solid fuel generation is zero and oil use is almost eliminated as the vast majority of the islands are connected to the mainland grid by 2030. There is no difference in NG installed capacity, but production in NECP23 compared to NECP19 is lower by 35%, an amount that is replaced by the enhanced RES deployment. The LTS2050 installed capacity and production in 2030 is very close to that of NECP19, as this was an explicitly stated condition of the LTS2050 modelling.

The major difference between NECP23 and both NECP19 and LTS2050 is in wind energy. The NECP23 calls for 10.5GW onshore wind and 17.3GW offshore by 2050. Such development of offshore wind seems unlikely. Presumably it is guided by the difficulties onshore wind will phase because of local opposition, but it presupposes that offshore wind is mostly floating wind turbines in view of the large coastal depth of the Greek seas and that their cost has decreased enough to make their use economically viable. In this, it is of interest to examine the capacity factors implied from the installed capacity and production values. It is widely accepted that offshore capacity factors should be above 42-45% for economic viability. The capacity factors for offshore wind in the NECP23 (with availability 95%) vary starting from a unrealistic 47% (values only seen in North Sea) in 2030 for the 2.7GW inscribed already and decreasing to ca 40% for the period to 2050. The only value available for NECP19 is for all wind including both on and offshore and only for 2030 so no comparison is possible.

For onshore wind the capacity factors (with 97% availability) start again from a realistic 27% in 2020 and increase to 29% in 2030, 34% in 2040 and reach a very unrealistic 39% in 2050, almost the same as the offshore. In the LTS2050 scenarios no separation of capacity and production between on- and offshore is available. The mean capacity factors are 38% for the EE1.5 and 41% for the NC1.5 scenarios.

For PV, the capacity factors vary between 18% and 19% for both NECPs and the LTS2050 except for 2025 for which in the NECP23 reaches an unrealistic 23.2%.

Table 5	Electricity Installed Capacity [GW]								Net Electricity Generation [GWh]							
	NECP-2019 and NECP-2023						EE1.5	NC1.5	NECP-2019 and NECP-2023						EE1.5	NC1.5
	2015	2020	2025	2030	2035	2040	2050		2015	2020	2025	2030	2035	2040	2050	
Total Installed Capacity																
NECP-2023	19.1	21	26	36.3	41.1	50.8	75.1		39458	38578	61430	69062	81418	107818	171134	
NECP-2019		21.1	23.1	26.3						52380	54283	57218				
LTS2050				31.7			38.8	71.8			0	61300		0	95800	169600
Solid Fuels (Lignite)																
NECP-2023	3.9	2.9	1.5	0	0	0	0		19900	5900	9600	0	0	0	0	
NECP-2019		3.9	0.7	0						8114	4536	0				
LTS2050				0			0	0				0			0	0
Oil Products																
NECP-2023	2	1.8	0.8	0.7	0.6	0.4	0.2		5381	4500	2300	1900	1600	1100	400	
NECP-2019		1.9	1	0.3						3597	2209	828				
LTS2050				0			0	0				0			0	0
Natural Gas																
NECP-2023	5.1	5.3	6.9	6.9	5.8	5.1	5.1		8900	18800	17100	12000	5600	7400	10700	
NECP-2019		5.2	6.9	6.9						22963	19169	18304				
LTS2050				7.1			4.9	7.9				20400			8300	23700
Hydro																
NECP-2023	3.3	3.5	3.4	4	4.1	4.2	4.7		6100	3400	6300	7100	7400	7500	7100	
NECP-2019		3.4	3.8	3.9						5453	6528	6596				
LTS2050				4			4.7	5.1				7000			8400	9200
Wind																
NECP-2023	2.1	4.1	5.6	7.1	7.4	8.1	10.5		4600	9300	12100	18000	21700	23200	34400	
NECP-2019		3.6	5.2	7						7280	12610	17208				
LTS2050				10			12.8	17.5				18000			41300	60900
Wind Offshore																
NECP-2023	0	0	0	2.7	5.3	10	17.3			0	0	10600	17800	34800	57400	
NECP-2019									Included in wind onshore							
LTS2050				0.3			0.5	2.2	Included in wind onshore							
PV																
NECP-2023	2.6	3.1	7.3	14.1	16.5	21	34.5		3930	4900	14400	19800	25900	32800	56500	
NECP-2019		3	5.3	7.7						4548	8202	11816				
LTS2050				9.7			14.7	37.3				11200			24000	58900
Other (bio, Geo, Solar thermal)																
NECP-2023	0.1	0.3	0.5	0.8	1.4	2	2.8		253	500	700	2000	3500	5100	7100	
NECP-2019		0.1	0.2	0.5						425	1029	2466				
LTS2050				0.6			1.2	1.8				4700			13800	16900

Overall, NECP23 is much closer to the NC1.5 scenario of LTS2050 both as to total capacity installed and electricity produced. The RES contribution reaches 95% as regards production by 2050 vs 91% and 86% for the EE1.5 and NC1.5 scenarios respectively and 93% vs 87% and 89% as regards installed power.

Net imports of electricity are seen to reduce to current levels of ca 4000GWh (3552GWh in 2022) and remain at that level for the whole period to 2050 for NECP23 as well as in the EE1.5 and NC1.5 scenarios. Given the tripling of total generation by 2050, the percentage of net imports decreases to less than 3% by 2050 from near 8% currently.

The tripling of RES electricity production and especially that of PV would require for grid stability purposes substantial storage from the current 600MW of pumped storage available. In Table 6 the projected amounts of storage in NECP23 as well as in NECP19 and the two LTS2050 is provided.

Table 6: Storage Installed Capacity [GW]

NECP-2019 and NECP-2023								
	2015	2020	2025	2030	2035	2040	2050	
NECP-2023								
Hydropumping	0.7	0.7	0.7	2.5	2.9	3.6	5.2	
Batteries				5.6	7.4	9.7	23.3	
Electrolyzers				1.2	2.4	6	14.7	
NECP-2019								
Hydropumping	0.7	0.7	1.5	1.5				
Batteries				1.3				
Electrolyzers								
LTS2050							EE1.5	NC1.5
Hydropumping				1.5			1.7	1.5
Batteries				1.2			2.5	3
Electrolyzers				0			4	23.5

The storage installation inscribed in NECP23 is very high and its timing starts very early as by 2030 it reaches 8.1GW hydropumping and batteries as opposed to 2.8GW in NECP19 and 2.7GW in LTS2050. In view of the limitations in pumped storage, batteries are called to play a very large role already starting in 2030 with 5.6GW triple that of NECP19 and reaching 23.3GW by 2050. Unfortunately, investment costs for the batteries are not provided but are incorporated in the investments of all electricity production (€1454Million/yr) and that, only up to 2030, so no conclusion can be reached as to the battery cost and its evolution to 2050. The amount of electrolyzers included in NECP23 is seen to be much smaller than the one in the NC1.5 scenario of LTS2050 with which NECP23 is very close in many other parameters. This might explain the large number of batteries as opposed to larger direct use of RES electricity in electrolyzers to produce H_2 as a means of storage which was the approach taken in the NC1.5 but not in the EE1.5 scenario.

Finally, NECP23 includes information on grid losses which vary from a minimum of 412ktoe in 2020 to a maximum of 503ktoe in 2045. This almost constant amount of grid losses seems unrealistic in view of the tripling of electricity generation and transmission.

3. The Sectoral underlying parameters and items of interest

The detailed review of energy use per sector that follows has made use of all available information. It would have been more complete if, in addition to factors affecting energy demand per sector, sectoral energy use per energy carrier were also provided. This would have made analysis of H_2 and synfuel production and consumption broken down in direct and feedstock demand, and thus their role in reducing emissions while meeting demand in an economically optimal way, clearer.

3.1 Transport Sector

In Table 7 the basic parameters that shape the energy consumption and emissions of the Transport sector, namely passenger and freight kilometers, passenger vehicle number and the breakdown between BEV and PHEV, and internal combustion (ICE) of the passenger fleet and the resulting use of electricity.

The NECP23 is seen to assume a slightly higher amount than the NECP19 (by ca 10%) of passenger-kilometers which is most likely the result of the omission in NECP19 of inland water passenger transport. In 2030 The passenger-kilometers (excluding extra EU aviation) of the NECP23 are in good agreement with the LTS2050 scenarios.

The percentage of the low emission vehicles (BEV and PHEV) in the fleet is seen in NECP23 to increase very fast and reach double percentage in 2030 compared to NECP19. By 2050 it has reached 80% with the rest 20% presumably being ICE vehicles hybrid or conventional using fuel either gas or liquid. The NECP23 also assumes that the use of electricity covers 98% of passenger demand by 2050 which is in accord with the minimal emissions (0.5 $MtCO_2$) at that year. Yet elsewhere in the NECP23 the percentage of electricity use in passenger transport is given at 85% with the rest comprising H_2 (13%) and conventional fossil fuels (7%). Not enough additional information is provided in NECP23 to resolve the discrepancy.

Table 7: Transport Sector

	NECP-2019 and NECP-2023						EE1.5	NC1.5
	2015	2020	2025	2030	2035	2040	2050	
Passenger Transport Demand (Gpkm)								
NECP-2023	158	136	174	186	204	205	214	
NECP-2019 (w/o domestic maritime)		128	157	166				
LTS2050	148			185			222	223
BEV & PHEV passenger vehicles (% of fleet)								
NECP-2023	0%	0.1%	2.1%	18.5%	38.0%	55.9%	80.5%	
NECP-2019		0.1%	3.0%	9.0%				
LTS2050				8.0%			98%	93%
Use of electricity in passenger vehicles								
NECP-2023		1%	4%	20%	48%	73%	98%	
NECP-2019		0%	1%	2%				
LTS2050				30%			39%	38%
Passenger vehicles (1000s)								
NECP-2023	5106	5061	5192	5181	5202	5104	5178	
NECP-2019		5492	4803	5043				
LTS2050 (including ca 1600 2W)				7400			8204	8143
Freight Transport Demand (Gtkm)								
NECP-2023	27	28	34	37	36	36	39	
NECP-2019		24	28	31				
LTS2050	27			36			46	48

Comparing NECP23 with the LTS2050 scenarios in the period 2030-2050 two differences are noted: (a) the increasing tendency of the number of vehicles in both LTS scenarios despite a substantial decrease in population of ca 8%, which raises questions and (b) the reliance of the LTS2050 on bio and synfuels at a much larger percent (43% and 50% for EE1.5 and NC1.5 respectively) coupled by the low electricity use of only 38% which is in line with the double number of electrolyzer installation in the NC1.5 LTS2050 scenario. It should be added that in both these two scenarios, fossil fuel use still amounts to 18% and 12% in 2050.

The increase of road passenger-kilometers from 126Gpkm in 2015 to 157Gpkm in 2050 coupled with the constant number of vehicles, the constant percentage of rail use of around 2% for the whole period and the reduction of population toward 2050 implies that if the average distance travelled by car remains more or less the same, the occupancy rate has to increase by 35% which would require a considerable change of behaviour habits by the general public.

For Freight transport only limited information is given in NECP23. The ton-kilometers are in absolute terms higher than those in NECP19 by 2030 even though the rate of increase is approximately the same. Compared to the LTS2050 scenarios, NECP23 Gtkm are the same in 2030 but are notably smaller by 2050 from those of the LTS2050 scenarios possibly due to lower GDP.

A further comparison of energy use breakdown by fuel in Freight is not possible because of the way maritime bunkers as well as international aviation outside EU are accounted (or not) in the data.

In both the passenger and freight subsectors, it is disheartening that the percentage use of rail remains more of less constant and rather small, that is 2.5% for passengers in 2050 (vs. 2.3% in 2015) and 1.5% for freight (vs. 1.8% in 2015). The use of rail in the LTS2050 scenarios is also very small and very close to that of NECP23.

3.2 Residential and Tertiary Sectors

In the Residential Sector, efforts to reduce energy use and emissions are along three pillars, namely (a) the improvement of the building insulation by renovation and by new construction to replace demolished older buildings, (b) the reduction of energy use through the improvement of the performance of the heating and cooling equipment and other household appliances and (c) the change of the consumption behaviour patterns of the general public in their residences. Although an attempt was made in this work to examine these three components individually, the information available (as for example data on energy savings with respect to a Business-as-Usual scenario which is not provided) was not sufficient to do so satisfactorily.

A comparison of NECP23, NECP19 and of the two LTS2050 scenarios is provided in Table 8. By 2050, both NECP23 and the LTS2050 scenarios incorporate renovation of close to 45% of the building stock with another ca 27% comprising new builds with tighter energy specifications, some of which have already being legislated. Renovations will result in energy savings between a high of 76% wrt to the energy used for heating in 2030 down to 37% in the 2040-2050 by which time the most energy inefficient buildings would have already been renovated.

The expenditure in NECP23 shown in Table 8 though compared to the number of building renovated annually results in only €10240/renovation, an amount that does not lead to deep cuts of energy demand for thermal needs. The expenditure in NECP19 is lower (€8520/renovation) while in the two LTS2050 scenarios the expenditure is higher (€14770 and €12970 per renovation for EE1.5 and NC1.5 respectively).

The NECP23, unlike NECP19, also includes information on the stock of appliances and means of heating/cooling including their numbers and efficiency. As regards air conditioning units, the almost fourfold increase between 2020 (5.4million) and 2050 (21.8Million) is extraordinary and arguably unrealistic and unnecessary. This increase in stock is accompanied with an equally large increase of COP from 3.03 in 2050 to an extraordinary 6.84 in 2050. The same pattern is seen in home appliances which increase by 50% (white appliances from 14.0Million in 2020 to 21.2Million in 2050, dark appliances from 33.1million in 2020 to 64.3million in 2050) while their efficiency increases by ca 40%. These stock amounts correspond, in view of the number of households, to more than 4 air conditioning units and almost 3 refrigerators per household and in 2050! Analogous information is not available for the LTS2050 scenarios. At the same time, heat pumps are seen to increase from 10.000 in 2020 to 1.79milllion by 2050, going from 1.5% of the heating/cooling systems in 2020 to 21.9% in 2030 and reaching 41.8% in 2050.

The overall result is the reduction of the energy intensity in the Residential Sector from 97kWh/m^2 to 78kWh/m^2 in 2030 and 54kWh/m^2 in 2050.

Turning to the Tertiary Sector, in NECP23 the FEC amount reported (see Table 3a) includes energy use from the Agricultural Sector which is typically ca 10-15% that of the Tertiary Sector. As no information is given for the Agricultural Sector separately the FEC of the Tertiary Sector can only be approximated: data for the Useful Energy consumed though are available and range from 1867ktoe in 2015 to 2769ktoe in 2030 after which date, the Useful Energy consumption remains at the same level of ca 2750ktoe till 2050. No corresponding data are available either for NECP19 or for the LTS2050 scenarios.

Table 8: Residential Sector

	NECP-2019 and NECP-2023						EE1.5	NC1.5
	2015	2020	2025	2030	2035	2040	2050	
Stock of buildings (1000s)								
NECP-2023	4370	4390	4370	4330	4310	4300	4280	
NECP-2019		4300	4300	4300				
LTS2050				?			?	?
Renovation rate (% of stock)								
NECP-2023	3.0%	7.0%	12.0%	19.0%	25.0%	31.0%	43.0%	
NECP-2019		4.7%	9.3%	14.0%				
LTS2050				16.7%			47.1%	43.1%
Annual renovation expenditure (Million €)								
NECP-2023		0	473	815	?	?	?	
NECP-2019		0	593	593				
LTS2050				593			838	616
New builds rate (% of stock)								
NECP-2023	7.0%	11.0%	15.0%	18.0%	21.0%	23.0%	27.0%	
NECP-2019		11.0%	14.0%	17.0%				
LTS2050				17.0%			27.0%	27.0%

Renovation also is envisioned for the Tertiary Sector. The rates and expenditures are given in Table 9. There does not seem to be any substantial differentiation from what NECP19 or the LTS2050 scenarios called for.

Table 9: Tertiary Sector								
	NECP-2019 and NECP-2023						EE1.5	NC1.5
	2015	2020	2025	2030	2035	2040	2050	
Stock of buildings (1000s)								
NECP-2023	250	209	229	239	246	252	252	
NECP-2019								
LTS2050				?			?	?
Renovation rate (% of stock)								
NECP-2023	2.0%	4.0%	5.0%	7.3%	10.7%	14.0%	21.0%	
NECP-2019								
LTS2050				5.7%			24.1%	21.7%
Annual renovation expenditure (Million €)								
NECP-2023		0	169	120	?	?	?	
NECP-2019			132	132				
LTS2050				128			207	181

In the Tertiary Sector, efficiencies (useful/final energy) for air conditioning are assumed to vary from ca 2.5 in 2015 to 3.28 in 230 and on to 3.64 in 2050. These values are significantly different from those in the Residential Sector that start again at 2.5 in 2015 but increase substantially and reach 6.84 in 2050 double that for Tertiary use. This discrepancy is not present in the efficiency of heat pumps for heating which is similar in both Sectors.

3.3 Industrial Sector

In the Industrial Sector, the two main indices of interest are (a) the output and (b) the energy intensity which may be expressed as energy consumed either vs. output or vs value added in economic terms. The NECP19 only includes intensity indices in terms of energy vs value in €.

In Table 10 indices for the output of the main sectors of industry are presented for NECP23 and the LTS scenarios. In 2030, the main sector with noticeable difference is that of Non-ferrous metals which is dominated by aluminium production for which NECP23 indicates a large increase by 44% vs only 16% for the LTS2050 scenarios. A noticeable difference is also found in Glass, but this sector has very small production (only one enterprise is still active) and thus energy consumption and GHG emissions are very small in absolute terms. In 2050, the picture is different. Whereas aluminium production remains constant after 2030, as is that of Non-ferrous metals. Both Chemicals and Non-metallic minerals output keeps growing with their difference from the LTS2050 increasing. The 50 % increase in Steel and Non-ferrous minerals which are mostly cement might be the result of increased activity in the building sector. Yet as this increase is seen to take place by 2030, it raises questions as regards the availability of financing for this construction activity in such short period. The LTS2050 scenarios do not envision large increases in Non-metallic minerals but do include the 50% in Steel possibly because of the large, under-utilized capacity in this sector.

Table 10: Industry Physical Outpur Indicator 2015=100%							
	2015	2030			2050		
	All	NECP23	EE1.5	NC1.5	NECP23	EE1.5	NC1.5
Steel	1.00	1.50	1.51		1.48	1.40	1.53
Chemicals	1.00	1.21	1.09		1.37	1.07	1.11
Non ferrous Metals	1.00	1.44	1.16		1.44	1.14	1.32
Non-metallic Minerals	1.00	1.16	1.06		1.41	0.93	1.06
Glass	1.00	0.91	1.13		1.03	1.27	1.45

Turning to the second index, that of energy intensity, in Table 11 a comparison of both NECPs and the LTS2050 scenarios is presented. The NECP23 intensity is seen to improve less than those of the NECP19 and the LTS2050 scenarios. Unfortunately, no data for energy consumption is provided per Industry sector to be able to also estimate energy use per unit of output for NECP19 or for the LTS2050 scenarios. Looking though in the sector breakdown in the NECP23, Steel and Non-metallic minerals have a 30% reduction in energy per unit output between 2015 and 2050 while Chemicals and Non-ferrous metals reach a 50% improvement which together lead to the ca 40% overall efficiency improvement shown in Table 11.

Table 11: Energy Intensity in Industry (energy/VA) 2005=100%								
	NECP-2019 and NECP-2023						EE1.5	NC1.5
	2015	2020	2025	2030	2035	2040	2050	
NECP-2023	9%	6%	-2%	-6%	-24%	-27%	-34%	
NECP-2019		6%	-8%	-17%				
LTS2050				-18%	-36%	-44%	-53%	-48%

3.4 Imports

Of interest is also to examine imports. The two main ones, oil (larger by more than an order of magnitude from the second NG) and NG, follow diverging paths as by 2040 NECP23 imports are half of those for NECP19. Oil imports by 2050 are almost all feedstock to refineries to cover inland consumption (about 12% including bunkers) and the rest for export. It should be mentioned that in 2021 nearly 2/3 (21.1Mtoe out of 32.3Mtoe) of the refineries output is exported.

Table 12: Imports (by Fuel)								
(ktoe)	NECP19 and NECP23						EE1.5	NC1.5
	2015	2020	2025	2030	2035	2040	2050	
Oil Products								
NECP23	33377	33380	32770	30749	24951	16715	7133	
NECP19		33885	33445	31800	30974	30128		
LTS2050								
Natural Gas								
NECP23	2680	4468	3606	3123	1698	1314	755	
NECP19		5230	4784	4800	4238	4230		
LTS2050				3422				
Electricity								
NECP23	826	750	97	201	179	351	212	
NECP19		533	425	394	411	429		
LTS2050				421			292	292

Net electricity imports are close for the two NECP versions as well as for the LTS2050 scenarios. The NECP23 shows large variations which most likely reflect small deficits in meeting electricity demand in view of decommissioning of fossil fuel plants and installing RES. A more detailed analysis of net electricity imports would require a larger regional modelling that includes all neighboring countries and grid stability considerations which might be beyond the scope of the NECP modelling. To accommodate short-term needs NECP23 includes an increase by 2030 of interconnections (to Bulgaria) capacity by 600MW which might be obligatory to meet EU-wide grid adequacy requirements.

As a result, the energy import dependence index for NECP23 is much lower than that of NECP19. By 2030 it drops to 61% for NECP23, decreases to 26% in 2040 (as opposed to ca 65% for NECP19) and drops to less than 10% in 2050.

4. Economic aspects and Investment

The investment needs broken down by sector for NECP23 together with those for NECP19 and the two LTS2050 scenarios are given in Table 13. These are average yearly values for the 2020-2030 period for the NECPs and the 2030-2050 one for the LTS2050 ones. For the LTS2050 scenarios in the 2020-2030 period, the NECP19 values should be assumed.

Table 13: Investment by Policy Sector (mil€/yr)

	NECP19 for 2020-30	NECP23 for 2020-30	EE1.5 for 2030-50	NC1.5 for 2030-50
Industry	109	195	349	397
Residential-Building upgrading	593	644	839	618
Residential-household equipment purchases	3,488	6,755	4,550	3,761
Tertiary/agriculture -Building upgrading	144	145	217	208
Tertiary/agriculture equipment purchases	1,072	2,758	1,231	1,151
Transport	10,878	13,249	13,062	13,390
Electricity generation	1,264	2,013	820	2,002
Grids	831	964	1,241	1,215
Other	12	323	105	818
Total	18,390	27,044	22,414	23,560
Total w/o transport	7,513	13,795	9,352	10,170
As % of GDP (w/o transport)	3.9%	7.2%	2.6%	2.9%

The NECP23 calls for 47% higher investments in the 10-year 2020-2030 period fairly evenly distributed over the period except for electricity and transport sectors for which there is a difference of 30% between the 2021-2025 and 2026-2030 periods. The Residential household and Tertiary equipment purchases, and the electricity sector investments are seen to almost double in the NECP23 compared to NECP19 while the transport sector, which in both NECP versions accounts for half of the total investment needs, shows a ca 25% increase. Even though NECP23 (or NECP19 for that matter) do not provide data for the 2030-2050 period, in view of the similarities of NECP23 with that of NC1.5, its investment figures can be assumed to be a first order approximation of the NECP23 investment requirements beyond 2030. The enhanced needs in the NECP23 are also reflected as a percentage of the GDP which for NECP23 reach 7.6% in the 2026-2030 period.

In view of the investment amounts shown in Table 13, by 2030 the yearly cost to consumers for NECP23 reaches €46.54Billion (23.3% of GDP) vs €38.02Billion (15.5% of GDP) for NECP19, an 8% increase. As Greece does not produce any vehicles or appliances and with RES equipment (which represent ca. 60% of the total needs) having only a ca 20-25% local content, this investment amount poses problems in trying to reduce the already very high National Balance of Payments deficit.

5. Some Overall Comments

In the previous sections the main features and quantitative information of the undated NECP to be submitted by June 2023 have been presented and where possible compared with both the NECP submitted in 2019 and the LTS Roadmap to 2050 Net Zero scenarios. The stated intention of the Ministry for Greece to be among the first to submit an updated NECP, combined with the possibility that elections due before July 2023 will be brought forward has resulted in a process and a draft that leaves a lot to be desired.

A first major shortcoming is the process itself. The NECP23 draft was made public by the Minister for Environment and Energy in a formal press conference on 16 January 2023 and comprised a PPT deck of 28 slides plus some 24 leaked additional slides with information for specific sectors. No accompanying text with detailed descriptions of policies and measures to realize the very ambitious targets for building renovations, vehicle fleet renewal and RES installations has been released during the press conference or since. This raises doubts about the status and fate of the draft updated NECP. The June 2023 deadline for the upcoming elections does not provide a time window for the release of a complete draft, the subsequent public consultation period and the rewriting to take into account submissions. Furthermore, the election will probably result in a change of the political leadership of the Ministry for Environment and Energy regardless of the outcome of the elections, which might lead to a revision, possibly in-depth if a different party or combination of parties win.

Regardless of its fate, the draft NECP in its present form, includes a number of inconsistencies and ambiguities that make assessment difficult. Examples include (slide numbering refers to 16 January 2023 version #5):

(i) The figure (Slide 9} for FEC by sector is mislabelled as it shows Gross FEC
(ii) The values for aluminium as well as iron & steel production differ between Slide 36 and Slide 43
(iii) The values for cement differ between Slide 37 and Slide 43
(iv) The text for footnotes that appear in a number of slides is missing.
(v) Units are mislabelled (for example energy intensity in the industrial sector)
(vi) The label for investment needs including transport (Slide 24), is mislabelled.
(vii) The FEC value for 2015 is given as 16.59Mtoe as opposed to 15.74Mtoe inscribed in the 2015 Energy Balance of Greece (2023 edition).

From the above, the need for a more careful proofreading becomes paramount.

In the same vein of presentation shortcomings, providing data for scenario A and B only for the 2020-2030 and not further out to 2050 does not facilitate the comparison between them and with the proposedly selected A/B scenario.

The absence of a full exposition, which might include more detailed information on PaMs and discussion of assumptions and rationale notwithstanding, on a more conceptual basis, items that raise concern include:

1. For the 2019 NECP, the TIMES-MARKAL model of the Greek National Center for Renewable Source and Energy Efficiency (CRES) was utilized. Computations were also carried out in parallel utilizing the PRIMES model. The PRIMES model is the only one utilized for the LTS 2050 results. As model biases are always present, the parallel utilization of the available TIMES=MARKAL model would be useful especially as it is already set up for this task.

2. The NECP23 calls for an increase of offshore wind by 2.5GW and of 1.9GW pumped storage, 200ktoe of H2 and 200ktoe synfuels by 2030. All these and especially that of offshore wind in view of limited experience with such installations in Greece, and pumped storage in view of licensing requirements seem highly unlikely if the need for grid upgrading is also taken into account.

3. The reduction of onshore wind from 17GW by 2050 in NECP19 to 10GW in NECP23 will require the call-back of operating licences already granted that go beyond the 10GW target which is bound to raise objections and lawsuits. This reversal between onshore and offshore wind is most likely an expedient political way to bypass the reaction of local communities to onshore wind park installations.

4. The NECP23 calls for a more than tripling of available biomass from ca 1500ktoe in the 2015-2030 period to ca 5100ktoe in the 2040-2050 period. Such an increase would need to be carefully planned especially as to land use and its availability. The LTS2050 scenarios also call for such an increase for which the needs just for energy crops might reach 439-480kha.

5. The CAPEX costs of the RES technologies, storage and electrolyzers are not given. Are the costs utilized in LTS2050 still applicable? This information is crucial to gage whether timing and prioritizing takes into consideration optimizing available investment but also cost to customers.

6. The capacity of NG plants is seen to increase to 6.9GW by 2030 which takes into account two new plants, one (of 826MW) ongoing acceptance test and the second (of 875MW) in the early stages of construction. The commencement of the construction of a third one already fully licenced has recently been announced. These will need capacity credit remuneration to be financially viable as will electrolyzers and batteries, which brings up the need for a clear analysis of the cost to the public. The information provided only goes to 2030 and is so scant that does not permit confident analysis and justification to consumers. In case these plants are envisioned to use H_2 or syngas with their higher fuel cost, the economic analysis needs to take this into account and also to assure that they are technically ready to do so.

7. The experience of the last two years has shown that projections of fuel prices are uncertain. The fuel prices in 2030 between NECP19 and NECP23 differ by as much as 300% and not in the very near years. This requires a sensitivity analysis which is not included.

8. The NECP23 proposes the scenario A/B as the one preferred of the three examined as a compromise between the other two, namely A with emphasis in RES accompanied by energy efficiency and B with emphasis in energy efficiency accompanied by RES development. In view of the 69.7GW of RES in A/B which is higher than the 63.1GW RES of the NC1.5 of the LTS2050, how larger (and realistic) would RES be in the A scenario. In any case, NECP23 should have provided information about the A and B scenarios so that the balance between A and B reached in A/B can be understood.

9. To reach net zero in 2050, a substantial amount of sinks form LULUCF will be required to offset the 9 $MtCO_2$ remaining. Of those 7 are from non-CO2 gases that include CH_4, N_2O that come to a large extent from the Agricultural sector, and F-gases. It is then surprising that there is no information provided for the AFOLU sector activity that has the largest reduction in emissions from 18 $MtCO_2$ in 2020 to 12.9 $MtCO_2$ in 2030 and 7 $MtCO_2$ in 2050 with the major, extraordinary (and unexplained) reduction from 18 $MtCO_2$ to 14.8 $MtCO_2$ in the 5-year period between 2020 and 2025.

10. GFEC in NECP23 goes from 17.7Mtpe in 2015 to 13.0Mtoe in 2050. The majority of the 4.3Mtoe difference comes from the Transport sector (2.68Mtoe), with the Residential also contributing 1.45Mtoe. The Transport reduction in turn comes mostly from the replacement of ICE vehicles with BEV/PHEV which are much more efficient, not from a reduction of passenger-kilometers which actually increases by almost 50%. Also in the Residential sector, the temperature set points assumed

are 20°C for heating and 24°C for cooling and the number of appliances and A/C units are seen to quadruple. These highlight the implicit downgrading of the "sufficiency" approach, an approach that is partly followed in the EE1.5 scenario of the LTS2050 which will clearly result in a lower overall investment need and a smaller cost to consumers.

The 2023 upgrade of the Greek NECP in its present form leaves a lot to be desired in form, substance and procedure. In form, the information released is so limited (the official release comprises 28 PPT slides) that it makes in depth analysis of the proposed policies and measures to achieve the emission reduction targets both in 2030 and 2050 well neigh impossible and certainly does not come close to meeting the template requirements, a large proportion of which are mandatory, of Implementing Regulation (EU) 2022/2299. The additional information in the informal 22 slides does not close to cover the gap nor does it provide explanations for the choices made and the financial requirements and their economic impacts. In substance, the choice of heavy reliance on high-RES deployment rather than on enhanced energy efficiency and sufficiency seems unbalanced and certainly debatable in view of the scant documentation provided for it. Finally, in procedure, this turns out to be another case that political expedience trumps well-documented policy proposals that can lead to truly long-term consensus strategy to reach a sustainable way forward.

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