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Investigating European Union Decarbonization Strategies: Evaluating the Pathway to Carbon Neutrality by 2050

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Abstract: Despite the rich and extensive documentation provided by European Member States and the European Commission in describing National Energy and Climates Plans and Long-Term Strategy plans, it is still very difficult to evaluate where and how the European Union as a whole has positioned itself on the path to achieving the Green Deal objectives, named the Fit 55% package in 2030 and the achievement of carbon neutrality by 2050. This research aims to fill this gap, proposing a simple but exhaustive semantic scaling methodology that allows, for the first time, a quantitative evaluation of the quality of the National Plans based on European Commission assessments to measure their compliance with the European Green Deal objectives. Results show that Member States have more clearly set the Green Deal targets than the actions to deliver against those targets. Actions, in term of nationals policies and funds administration, are still immature and partially addressed.

Keywords: semantic scale; National Energy and Climate Plans; Green Deal; net zero; policy review; Long-Term Strategy

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1. Introduction

The National Energy and Climate Plans (NECPs) and the Long-Terms Strategy (LTS) plans of Member States of the European Union (the EU27) determine the national contributions toward the European Union's (EU) energy–climate targets. They are, at present, the main "tools" to promote EU decarbonization. Those plans are mandated and reviewed by the European Commission (EC). NECPs and LTS are both policy tools and investment programs, providing businesses and investors with a forward-looking framework. Thanks to these plans, it is possible to keep track of the actions each Member State intends to pursue to accelerate the abatement of GHG emissions, boosting the circular economy [1,2] improving sustainability in exploiting resources, material flows and limiting waste [3] and reducing environmental and societal damages [4]. They are the basis for the Member States to plan their green recovery and sustainability strategies; thus, their analysis and assessment allow for evaluating how the EU27 is positioned concerning decarbonization objectives.

Despite the rich and extensive documentation provided by literature [5–9] and EC documents, a "measure" of the compliance of the Member States and EU27 with the 2030 and 2050 objectives is still not carried out, that is, in turn, the aim of this research. Quantifying the large set of categorical data contained in the plans is an innovative approach: it should be adopted in future reporting to highlight barriers and opportunities toward European Union decarbonization with the aim to further guide the EC in its targeted decision making.

The most recent NECPs (Final NECPs) were submitted by the Member States to EC at the end of 2019 and reported against the objective of the Regulation (EU-2018/1999) [10] that committed, collectively, to a 40% reduction in greenhouse gas emissions, a 32% increase in energy efficiency and a contribution of 32.5% of renewable sources in the energy mix by 2030 against the emission baseline in 1990. The "Green Deal" package—aiming for a 55% reduction in emissions compared to 1990 instead of 40%, a 39% in increasing

energy efficiency instead of 32.5% and 40% of renewables share against 32%, all targets by 2030—was proposed at the end of 2019 but approved only in 2021. The inclusion of Green Deal objectives into NECPs happened with the EU Climate Law [11], which entered into force on 29 July 2021. For this reason, the most recent available, final NECPs, are still set on the prior objectives.

The final NECPs are the results from previous Draft NECPs (submitted by 31 December 2018, under the Governance Regulation) that were analyzed by the EC, which then published an overall assessment and country-specific recommendations in June 2019 [12].

Earlier reports are available on the Draft NECPs' assessments, which claim that they are insufficient in addressing the Regulation objectives [13,14], while for Final NEPCs, only the EC qualitative assessments are available at the moment and are analyzed in depth for the first time in the present study.

Taking these recommendations into account, Member States were then required to submit their final NECPs by 31 December 2019. Then, the EC published a document on the cumulative impact (Wide Assessment, September 2020) [15] of the final NECPs and 27 Staff Working Documents [16] (SWD, 14 October 2020) that evaluated how the Member States considered the previous recommendations.

It is important to mention that NECPs report greenhouse gas (GHG) targets only for sectors included in the Effort Sharing Regulation (ESR). The Emission Trading System (ETS) (revised in 2018), in force before the Green Deal [17], delivers a 43% reduction in emissions for the sectors it covers by 2030 compared to 2005, consistent with an EU27 emissions reduction target of at least 40% by 2030 compared to 1990, and these sectors are therefore not an objective of the NECPs.

The Governance Regulation required the Member States to submit their first national Long-Term Strategy (LTS) plans to the EC by 1 January 2020. At present, not all the Member States have submitted their LTS. However, the plans received by the EC on 30 September 2021 are contained in a two-page document-Summary Tables [18]-summarizing the main content of each national Long-Term Strategy submitted so far.

The SWD mainly contain the EC "judgements" regarding how the Member States addressed the recommendations of June 2019 that helped to improve their draft into final NECPs. Similarly, Summary Tables contain judgements on how the plans were developed for the long-term objective of 2050 carbon neutrality.

In this paper we use the NECPs and SWDs to evaluate the EU27 Member States' progress towards the 2030 and 2050 targets of the EC. The paper is laid out as follows. First, we outline a methodology to develop a quantitative measure of progress for each Member State against the 2030 and 2050 targets. Then we present the results of this analysis and discuss our findings in the context of achieving the objectives as laid out by the EC. Finally, we conclude by looking at progress and suggesting where additional analyses can be conducted to enrich our findings.

2. Materials and Methods

2.1. Data Resources

The 27 SWD are the basis of the present study. They offer a comprehensive and extensive set of information in the forms of "judgements" (see ANNEX II table within each Member State SWD) that can be easily converted into numerical scales, which represent the quality of the plan in accomplishing the 2030 objectives (decarbonization, energy efficiency, energy security, internal energy market, research and innovation and competitiveness). A similar approach has been used for scaling the Summary Tables (Energy and Environment Assessment of the Long-Term Strategies of EU Member States).

A further resource that has been used to trace the evolution of the EU27 along the path to decarbonization is the Net Zero 2050 Report [14] by the Ecologic Institute that assesses the Draft NECPs (due by December 2018). This study represents the baseline of the NECPs evolution and assesses Draft NECPs according to the following:

(1) the adequacy of their national targets (in a net zero context);

(2) the completeness and detail of the policy descriptions;
(3) the quality and inclusiveness of the drafting process.

None of the previous resources (NECPs, LTS or Net Zero report) evaluate the likely effectiveness of the presented policies.

2.2. Scaling Methodology

Certain research data such as those on behaviours, opinions and attitudes are qualitative (categorical data). Evaluating leadership effectiveness, commitment, motivation and satisfaction involve measurement based on collected opinions/judgements, and these qualitative data can be measured using quantitative scales if a simple comparison is needed [19,20]; and, depending on the observed phenomena, several different scales are possible [21].

In the present study, due to the nature of the qualitative data gathered in the EC documents, the authors resort to a semantic interval scale. A semantic scale [22] rates an adjective or notion, and it is particularly efficient in expressing some level of intensity. It is characterized by a survey rating that is described by grammatically opposite adjectives at each end, for example, satisfied–unsatisfied, love–hate, good–bad and likely to return–unlikely to return, with intermediate options between the opposites. The analysis of the EC on the NECPs and LTS plans' effectiveness is conducted by employing qualitative judgments, judgements that express an opinion on the ability of the plans in accomplishing the desired objectives. This is the case of the SWD for the Final NECPs, where responses to recommendations are rated between "Not Addressed" and "more than ambitious", a scale of satisfaction measurement. Similar evaluations are present in the Summary Tables for the LTS assessment. Details are discussed in the next paragraphs.

2.2.1. NECPs Assessment

The assessment of the Draft NECPs according to the Net Zero Report [12] is discussed in the original document, and therefore the authors do not report the methodology here. Results of the Net Zero Analysis are discussed in the Results section.

The authors' method to assess the evolution of NECPs is based on the EC SWDs (October 2020) [9] regarding the assessment of the Final NECPs; SWDs report two summarizing tables:

1. Target Table: focuses on Member State's objectives, targets and contributions under the Governance Regulation;
2. ANNEX II: detailed assessment of how the EC recommendations to improve Draft NECPs have been addressed by the Member States in the Final NECPs.

The target table reports the assessment of the declared targets/contribution in 4 areas:

1. GHG binding reduction target (from 2005) under Effort Sharing Regulations;
2. Target for the percentage of renewables share in the national gross final energy consumption;
3. Energy efficiency in primary energy consumption;
4. Energy efficiency in final energy consumption.

ANNEX II reports the description of the compliance of the Member State plan with respect to the following 11 objectives:

1. Non -ETS GHG emissions: emissions reduction targets set in the Effort Sharing Regulation (ESR);
2. EU renewable energy: share of renewable energy under existing and planned measures;
3. Energy Efficiency: implementation of the "Energy Efficiency First" principle into legislation;
4. Energy security: importance of a resilient energy system with appropriate business continuity plans;
5. Internal energy market: well-functioning internal energy market provides price signals to guide investment in green energy and technologies, secures energy supplies and enables the least-cost path to climate neutrality through smart technologies;

6. Research and Innovation: R&I needs for delivering on climate and energy objectives;
7. Regional cooperation: increased cooperation between the Member States and multi-level dialogue;
8. Investment and funding: expected investments needed to achieve the various objectives, targets and contributions;
9. Energy subsidies: plan/list of actions to boost renewable; plan of phasing out energy subsidies for fossil fuels;
10. Air quality: measures on air pollution, linked to environmental legislation;
11. Just transition and energy poverty: measures to address the social and economic impacts of the transition, focusing on the regions, industries and workers who will face the greatest challenges.

In both tables, the assessment is expressed according to a qualitative scale based on judgments.

A qualitative approach is useful to guide further improvements of the plan, but it is not suitable to highlight which are the most challenging objectives across the countries, how many countries have set policies/actions to achieve a certain objective or how many countries have not, or only partially. Resorting to a numerical interpretation of EC assessment will help in realizing graphic representations of the path toward EU27 decarbonization. For this reason, the authors converted the set of judgments into "scores" according to a "semantic scale" principle.

Concerning the Target Table, the EC sets the following degree of judgment to evaluate the 2030 Ambition level of the 4 targets (Table 1).

Table 1. Semantic scale judgements to score conversion for the EC Recommendation assessment.

Targets' Judgement	Score
more ambitious	7
sufficiently ambitious (including "As in ESR")	6
adequate	5
not ambitious	4
modest	3
low	2
very low	1
not addressed (N/A)	0

In consequence, the maximum score for each country, in the case that all targets were more than ambitious, is 7 score × 4 targets = 28; if none were addressed the score is 0. Considering each target has equal weight, the range of scoring can be designed as in Table 2.

Table 2. Targets score assignment ranges of addressing according to EU Recommendations.

Level of Addressing	Ranges	
fully addressed	24	28
largely addresses	21	24
sufficiently addressed	17	20
partially addressed	12	16
low addressed	9	12
very low addressed	5	8
not addressed	0	4

Using this scoring mechanism, it is possible to classify the Member States' target ambition accordingly (see Supplementary Materials).

Regarding ANNEX II on the 11 objectives, the degree of judgement was simplified to 4 levels: N/A, partially, largely and fully. This is also a scale of satisfaction. However, ANNEX II tables are not the same for every Member State: the 11 objectives are the same, but each objective could require a different number of recommendations, depending on whether that objective was satisfied, or not, or partially in the Final NECPs. Each recommendation

within the same objectives could be fully, largely, partially or N/A. Moreover, there is a judgement set as "No Recommendation", which means the EC was fully satisfied with how that objective is addressed in the Final NECPs, and thus this judgment is considered "fully addressed".

To proceed with the score assignment, the reasoning is the following: if all the recommendations within the same objective are fully addressed, the objective obtains a score of 1 (see Table 3). It means that if within an objective there are 4 recommendations, each can contribute a score of 0.25, and their sum is equal to 1. If only 2 recommendations are fully addressed, while the other two are only partially, the sum of the 2 fully addressed recommendations will be 0.5, while for the two partially addressed, the 0.25 score will be multiplied by 0,5 (or divided by two), and the total score for that objective will be 0.25 + 0.25 + 0.125 + 0.125 = 0.75. The score is based on conversion Table 3.

Table 3. NECPs 11 objectives Judgements' conversions in Score.

Targets' Judgement	Score
Fully	1.00
Largely	0.75
Partially	0.5
N/A	0

To clarify further, consider for instance the following Table 4 that refers to the Austria Recommendations assessment. This table represents the conversion of EC judgments for Austria into scores according to the semantic scaling in Table 3. The same has been completed for the other 26 Member States and reported in Supplementary Materials.

Table 4. SWD ANNEX II table for Austria, evaluation of EC recommendations.

	Austria—Recommendations			
	Recommendations	**Recommendations per Objective**	**Assessment Judgement**	**Score**
1	Decarbonization—GHG	2	partially NA	0.25 0.00
2	Renewables share	5	fully fully partially partially fully	0.20 0.20 0.10 0.10 0.20
3	Energy efficiency	3	partially NA partially	0.17 0.00 0.17
4	Energy security	1	NA	0.00
5	Internal energy market	1	No rec	1.00
6	Research and Innovation	2	largely partially	0.38 0.25
7	Regional cooperation	3	partially partially partially	0.17 0.17 0.17
8	Investment and funding	2	largely partially	0.38 0.25
9	Energy subsidies	3	partially NA partially	0.17 0.00 0.17
10	Air quality	1	partially	0.50
11	Just transition and energy poverty	2	NA largely	0.00 0.38
	Total score			5.38

There are five recommendations on renewables share. Thus, to obtain the score of 1 (fully) for this objective, all 5 recommendations should be fully addressed. In the case of Austria (Table 4), they are not full addressed: 3 are fully addressed, and 2 are partially addressed. Thus, the full score is obtained by dividing 1 by the 5 recommendations, obtaining 0.20 score = fully. To this, 2 partially scores must be added: partially score is obtained by multiplying the fully score 0.2 × 0.5 = 0.1 partially score. Thus, the total score for renewables share for Austria is 0.2 + 0.2 + 0.2 + 0.1 + 0.1 = 0.8. Thus, as a general rule, the unit is divided, for each objective, by the correspondent number of recommendations; then with the help of Table 3, the full score is proportioned to the correspondent judgements. The process is summarized below:

1. Number of recommendations = "fully" score value based on the number of recommendations;
2. Fully score × judgement score (Table 3) = final score for recommendations;
3. Objective score = sum of scores for each recommendation due to that objective;
4. If a recommendation is N/A, the score is = 0;
5. If a recommendation is "No Recommendations", the score is = 1.

The EC considers all of the 11 objectives equally important. Therefore, this methodology gives the same importance or weight to all of them. In Supplementary Materials, the conversion of ANNEX II tables is reported.

In score assignment, with all the objectives fully addressed, the EU27 as a whole totalized 27 scores; if all Members address all the objectives largely, the total score would be 27 × 0.75 = 20.25; if Members address all the objectives partially, the total score for EU27 will be 27 × 0.5 = 13.5; below this score, the recommendations are, on average, not partially addressed or classed as a low level of addressing (Table 5).

Table 5. Score Range assignment for NECPs Recommendations.

Level of Addressing	Ranges	
fully/no recommendation		27
largely	>20.25	<27
partially	>13.5	<20.25
low	>0	<13.5
N/A		0

2.2.2. LTSs Assessment

The resources of the LTS plan and their assessment for each Member State are reported on the EC Energy, Climate change, Environment website, which collects the Summary evaluations tables [18] for each country. Those table reports information about the following topics:

1. Overall goal of LTS;
2. Scenarios presented in the LTS;
3. GHG reductions;
4. Renewable energy sources;
5. Energy efficiency;
6. Estimated Investment;
7. Socio-Economic Impact of transition;
8. Adaptation Policies measures;
9. Public Consultation;
10. Legal status of LTS and targets.

Similar to NECPs assessment, Long-Term Strategy plans can be measured with a satisfaction scale method. In the Summary Tables, the previous objectives have been assessed with a "value". The value expresses the following: if the objective is addressed with "information/data" (estimations, scenarios, models) or if it is addressed, for instance in terms of policy/actions, with a "yes", it is considered "satisfying" the assessment; if the objectives are limited, they are considered "partially satisfying"; and if they are not

addressed with "N/A", "No" or "Unspecified", they are considered "not satisfying". Conversions of values into the scores are in Table 6: there is a max 1 score if the objective is addressed, 0,5 if is addressed in a limited way, 0 score if the objective is not addressed, and not present (No) or not specified. The tables have the same structure for all countries.

Table 6. Value and score for the Summary Tables on Member States' Long-Term Strategies.

Targets' Judgement	Score
Quantitative data and information	1
yes	1
limited	0,5
N/A or No or unspecified	0

The results of the score assignments are reported in Supplementary Materials; the discussion of results in the Results session.

3. Results and Discussion

The results of the study are organized into two parts: results on NECPs assessment and results on LTS assessment. The EC assessments, both for NECPs and LTS plans, consider the context of recovery from COVID-19.

3.1. NECPs Assessment

NECPs results are in turn split into three parts: an examination of Target's ambition level (Target Tables), an examination of the recommendations for the 11 objectives (ANNEX II) and an assessment of NECPs for the EU27 as a whole.

3.1.1. Assessment of National Targets Ambition Level

Targets Ambitions level for the Member States are (Target Tables in the SWD):

1. GHG binding reduction target (at 2005) under Effort Sharing Regulations;
2. Target for the percentage share of renewables in the national gross final energy consumption;
3. Energy efficiency in primary energy consumption;
4. Energy efficiency in final energy consumption.

In Figure 1, the score for the NECPs targets for each Member State is presented; the scores are those reported in Supplementary data for each country in the first Table titled with the name of the "country—target" (for instance, "Austria—Target") at the row "total score". The total score represents the sum of the scores obtained for each target according to the authors' methodology (see Table 1).

Even though all economic sectors can contribute to emissions reduction, the NECPs' target highlights the central role of the energy sector in decarbonization strategy, as it requires massive GHG reduction, energy efficiency and renewable energy deployment.

As the main finding, any of the Member States achieving a score of 24 or more can be considered as fully addressing the EC recommendations. As can be seen, there are no countries that meet this threshold.

Eight countries, largely address the EU recommendations, 15 partially addressed the recommendations and 2 need to improve their plans according to the EC recommendations.

From the previous Member States' totals, GHG targets are compliant with the ESR targets for 2030 for all the countries. Going in-depth, target adequacy for GHG and renewable energy are better addressed in comparison to the targets related to efficiency in energy production and consumption.

These findings highlight that the "Energy Efficiency First" [23] principle (embedded in the Regulation), which should be a primary target for accomplishing an effective decarbonization pattern (Figure 2), is still not adequately addressed by the Member States. This Figure also proves the importance of the adopted methodology to represent categorial data trends and extract important information: the discrepancy between the renewable

energy and efficiency targets is not a minor barrier; it is present across all the Member States suggesting the need for further effort from the Member States to implement those target in the plans.

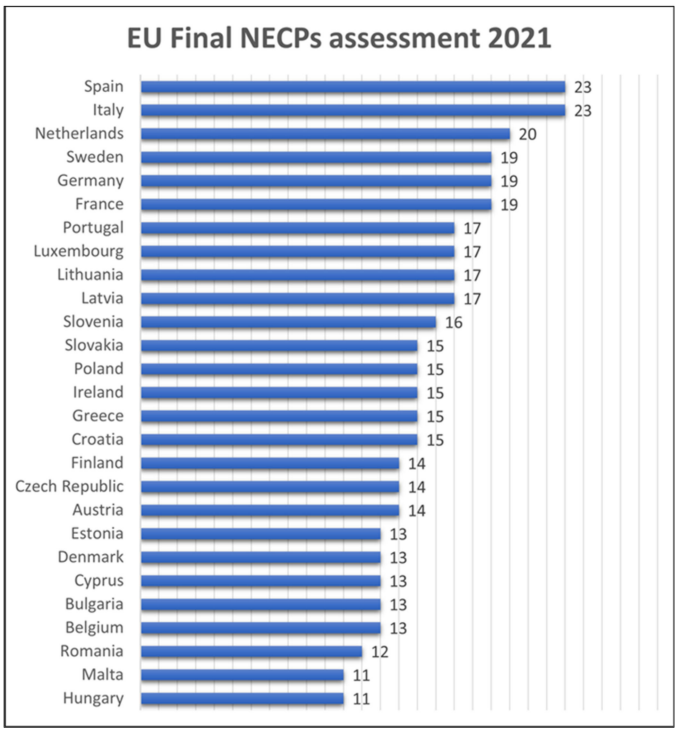

Figure 1. Representation of the level of ambition for the NECPs targets, classified according to the author's methodology.

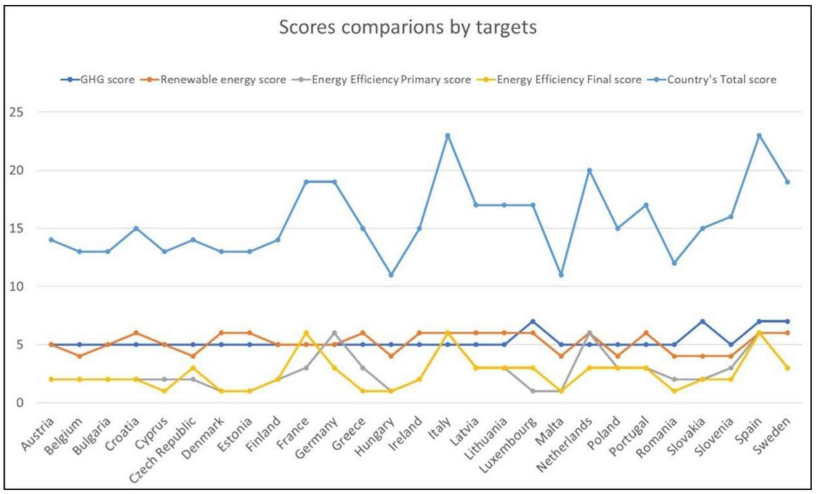

Figure 2. Discrepancies between the adequate targets defined by the Member States for GHG and renewables targets and the less performant targets in energy efficiency (Primary and Final).

3.1.2. Assessment of the Implementation of EC Recommendations

Aside from the assessment of the ambition level of the targets (renewable energy, energy efficiency and GHG reduction), the EC assessed the Members' plans under 11 objectives related to the action/policy each Member States plans on how to achieve the targets. To refine the analysis, barriers and opportunity in the decarbonization strategy can be highlighted by subgrouping the previous 11 points, as shown in Table 7:

Table 7. EU27 main objectives to be achieved with the National Climate and Energy plans.

GHG Reduction Target	Energy Production	Innovation	Social Impact
non-ETS GHG emissions	Energy security	Regional cooperation	Air quality measures
EU renewable energy share	Internal energy market	Investment and funding	Just transition and energy poverty
Energy Efficiency		Energy subsidies	
		Research and Innovation	

This subgrouping allows for an easier analysis of the position of the EU27 as a whole with respect to the 11 objectives. The idea is to sum the scores from the Member States for each objective.

In the following Figures 3–6, the results of the scoring for groups are reported.

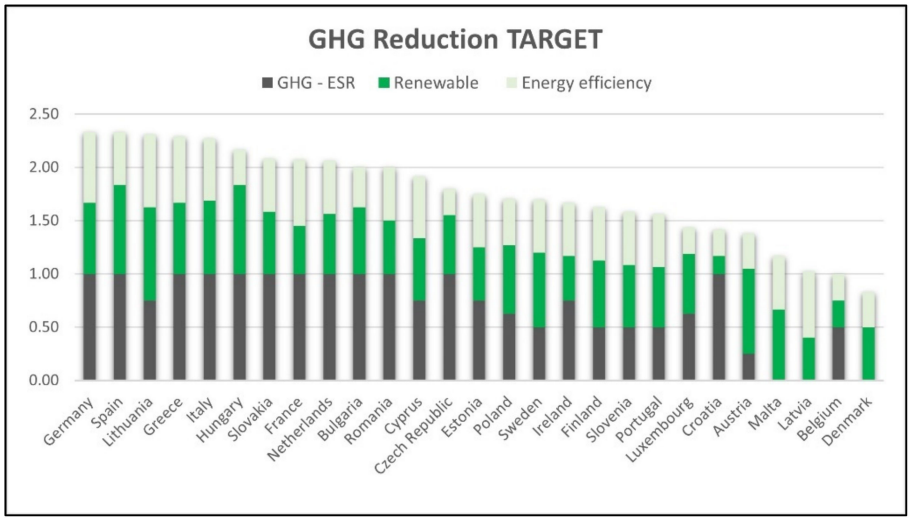

Figure 3. Non-ETS—GHG emissions, EU renewable energy and energy efficiency recommendations scoring for the Member States.

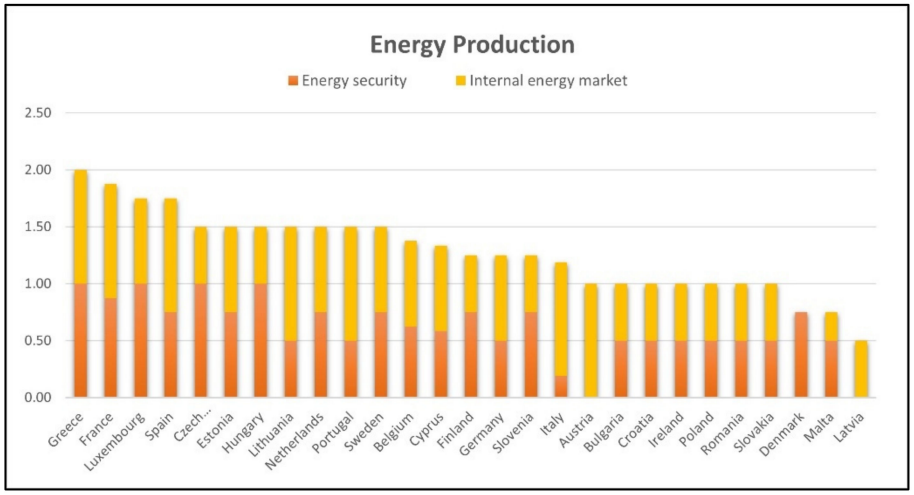

Figure 4. Energy security, internal energy market and recommendations scoring for each Member State.

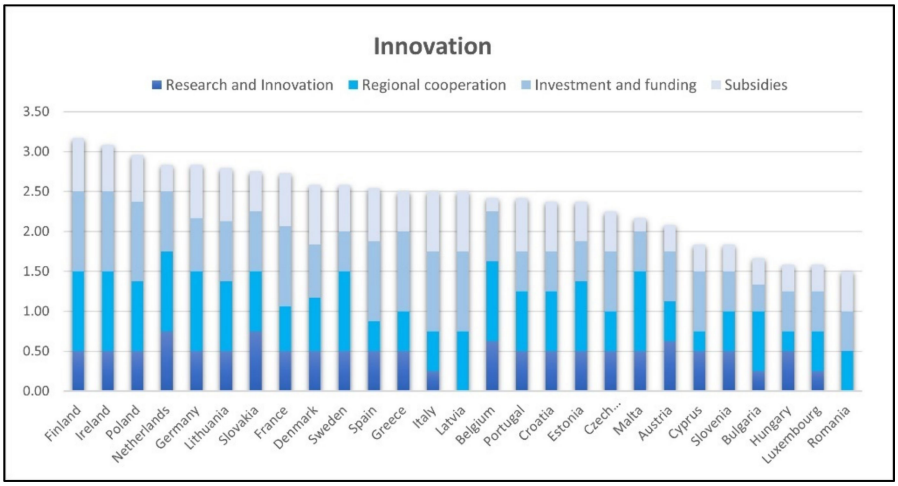

Figure 5. Research and Innovation, regional cooperation, subsidies and investment and funding recommendations scoring for each Member State.

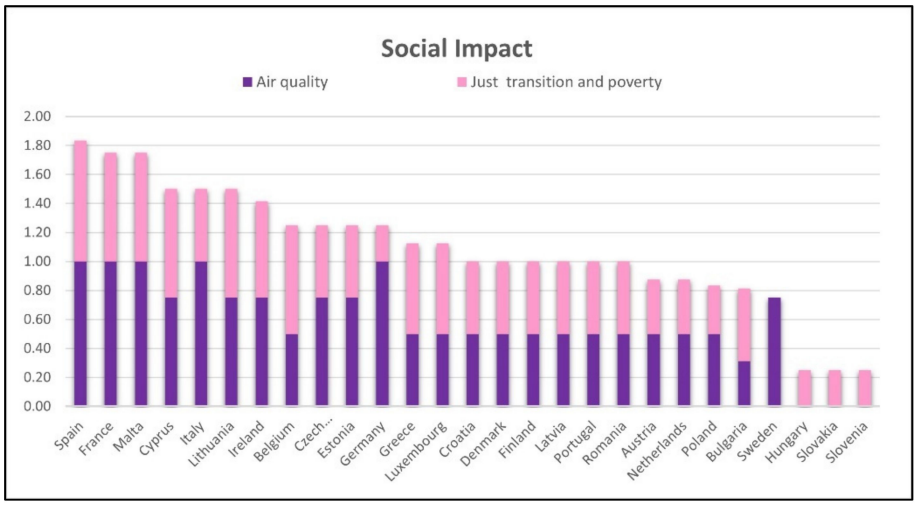

Figure 6. Air quality and just transition and poverty recommendations scoring for the Member States.

Figure 3 shows that GHG emission targets are fully and partially addressed for most of the Member States; renewables sharing implementations plans are partially and largely addressed by most, but none of the Member States fully address this objective. energy efficiency plans, which should support the previous two goals, are mainly partially addressed by most of the Member States.

We can also note that there are more renewables sharing recommendations for each member state than in other objectives. This is evident looking at the graduality of renewables scoring: the more recommendations per objective, the smoother is the scoring profile. This fact also evidences that a high number of recommendations denotes most NECPs have not yet obtained a clear plan for renewables implementation.

However, the decarbonization of the EU27 electricity supply infrastructure utilizing the integration of decentralized renewable energy sources requires further improvements as well as there being a need to lower the overall demand for electricity. The EC gave clear indications to achieve this reduction in demand: prioritizing energy efficiency in the supply chain, which is not yet sufficiently addressed as discussed before; and increasing efficiency in the building sector, which represent an intensive "consuming" sector [24,25]. The plans reveal that at moment, most of the EU27 countries were better prepared to adopt building renovation measures because they can be implemented locally. On the other hand, the transition toward renewable energy is progressing at different speeds among EU Member

States [26] (Figure 3) and this makes it difficult to implement an efficient cross border energy network based on renewables.

None of the Member States fully address (score = 1) recommendations on renewables, energy efficiency, Research and Innovation, subsidies, just transition and poverty. A few countries (Lithuania, Spain, Austria, Hungary) address renewables implementation with a score between 0.75–1 (almost Fully); energy efficiency is addressed by 7 countries (Lithuania, Germany, Latvia, Greece, France, Italy, Cyprus) with a score between 0.5–0.75 (largely); 4 countries 0.5–0.75 (largely, Slovakia, Netherlands, Belgium, Austria), for research and innovation; 13 Member States address Subsidies with 0.5–0.75 and only Spain addresses just transition and poverty >0.75 while another 8 Members (Malta, Lithuania, France, Cyprus, Belgium, Ireland, Luxembourg, Greece) had a score between 0.5–0.75.

Figure 4 shows that energy security and internal energy market targets are–on average-largely addressed by 11 countries and partially by most of the rest. This trend also reflects the divergent national energy security interests and leads to different energy policy strategies involving foreign actors. Moreover, a recent study shows that the digitalization of the energy market, is still bound to specific regions, often in the neighbourhood of capital cities [27] and special attention should be focused on energy-information systems to assure sufficient levels of cybersecurity not yet achieved EU [28].

Still insufficient is the effort to cut subsidies for fossils and to raise subsidies for renewables and greener energy production (Figure 5). Research and innovation investment should be increased in all sectors.

On the other hand, most of the Member States have set an ambitious non-ETS–GHG emission reduction target; regional cooperation is, on average, well-planned (between 0.5–1) for 17 Member States, with the same for the Investment and Funding. Internal energy market, energy security and air quality have been addressed more than partially only by a half of the 27 Member States (Figure 6).

Based on the scoring reported in Table 8 and the ranges of quality reported in Table 5, Figure 7 shows that GHG targets reductions are appropriately set and focused on the 2030 objective: renewables targets are, on average, largely set, while the energy efficiency target, as already commented upon, is not sufficiently set to achieve the desired decarbonization target. This fact mainly evidences that countries are mobilizing for renewables implementations but without conducting a commensurate effort to improve the efficiency of the present energy provisioning sector. Looking at new green technologies to produce energy is surely a positive signal; however, disregarding the efficiency of the present production processes, which cannot turn off rapidly, decreases the possibility of achieving the desired 2030 GHG reduction target.

Table 8. Objectives score as the contributions from each Member State to the EU27 as a whole.

Objectives	Scores
GHG	19.00
Renewables	15.79
Energy efficiency	12.71
Energy security	16.52
Internal energy market	18.00
Research and Innovation	12.50
Regional cooperation	18.98
Investment and funding	18.98
Subsidies	19.17
Air quality	15.81
Just transition and poverty	13.58

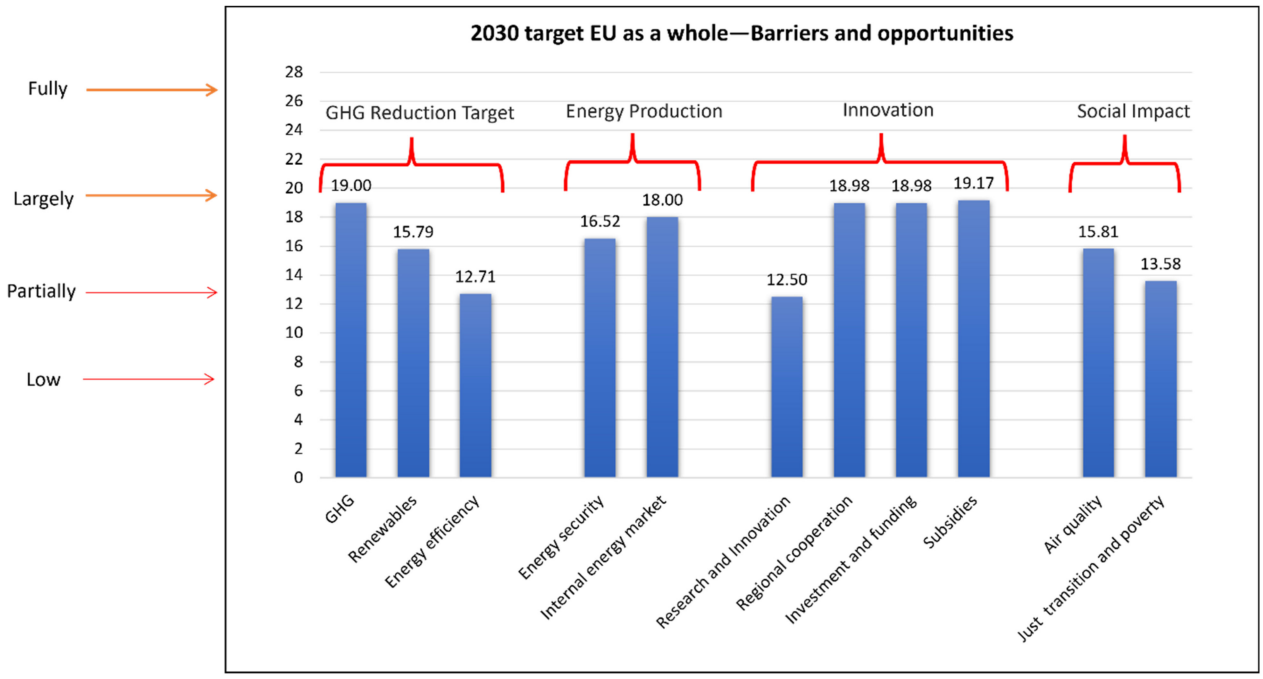

Figure 7. Barriers and opportunities in achieving 2030 decarbonization goal based on current NECPs. Most of the objectives are more than partially addressed, but not largely.

In energy production, energy security plans for resilient energy provisioning are promoted by most countries as well as internal energy market investment plans in green energy and technologies.

In Innovation, Research and Innovation (R&I) are still partially addressed on average across the Member States, highlighting, similarly to the target's objectives, a weakness in the strategy: resources are invested in new technologies, but R&I importance, on which the development of new technologies relies, is still partially considered by the Member States. In regional cooperation, each Member State should further promote regional projects, such as offshore wind power and rapid charging networks. To complete this, they should use investment funds [29], recovery funds [30], regional aid funds, as well as the EU renewable energy funding mechanism, making full use of the regional forums. Member States should also comply with the recommendation on the description and listing of energy subsidies, but the quality of information varies from general descriptions (21 countries) to extensive and quantified grant lists (6 countries). Only six countries have set a timetable for the phasing out of some of the existing fossil fuel subsidies [31].

Social Impact is only sufficiently addressed [32,33]; however, the "Fit for 55 packages" includes a regulation establishing a new Social Climate Fund [34] (SCF) as a consequence of the Green Deal establishment of an ETS for transport and buildings. The SCF aims to help vulnerable households, micro-businesses and transport users meet the costs of the green energy transition in the buildings and road transport sector and should be reported in the NECPs.

3.1.3. Assessment of Progress since the Draft NECPs

Here we discuss the current evolution of Member States NECPs comparing with an assessment of the Draft NECPs conducted by Ecologic Institute (EI) in 2019 [14] with the Final NECPs assessment provided in Section 3.1.2. In its 100 pages, EI analyzes the individual Energy Climate 2030 Plans one by one, returning a ranking of the nations most committed to the goal of zero emissions. The assessment methodology of the Draft NECPs according to the EI's Net Zero Report (NZR) is discussed in the original document and it is not duplicated here. The comparison aims to highlight the progress in the development of the NECPs' plans and to evaluate the response of the Member States to

the EC recommendations, in respect to the Regulation and the more challenging Green Deal objectives.

As a result of the NZR assessment, the Member States were ranked according to three criteria: the adequacy of the Target, Policy details and Process quality. The ranking data are retrieved from the report in Table "Target Adequacy Total" in Duwe et al. [14]; Table "Policy Details Total" in Duwe et al. [14]; and Table "Process quality total" in Duwe et al. [14].

Figure 8 shows Draft NECPs data of "target adequacy" versus data of "policy details": 11 countries did not show adequacy in the targets nor the policy; 11 Member states planned an adequate number of policies and actions in their plans, but they did not have the adequate ambition to achieve the desired targets. Three Member States had efficiently set ambitious targets in their plans, but they are not followed by adequate policies and measures to achieve them. Only three Member States (Spain, Sweden and Denmark) had proposed comprehensive plans.

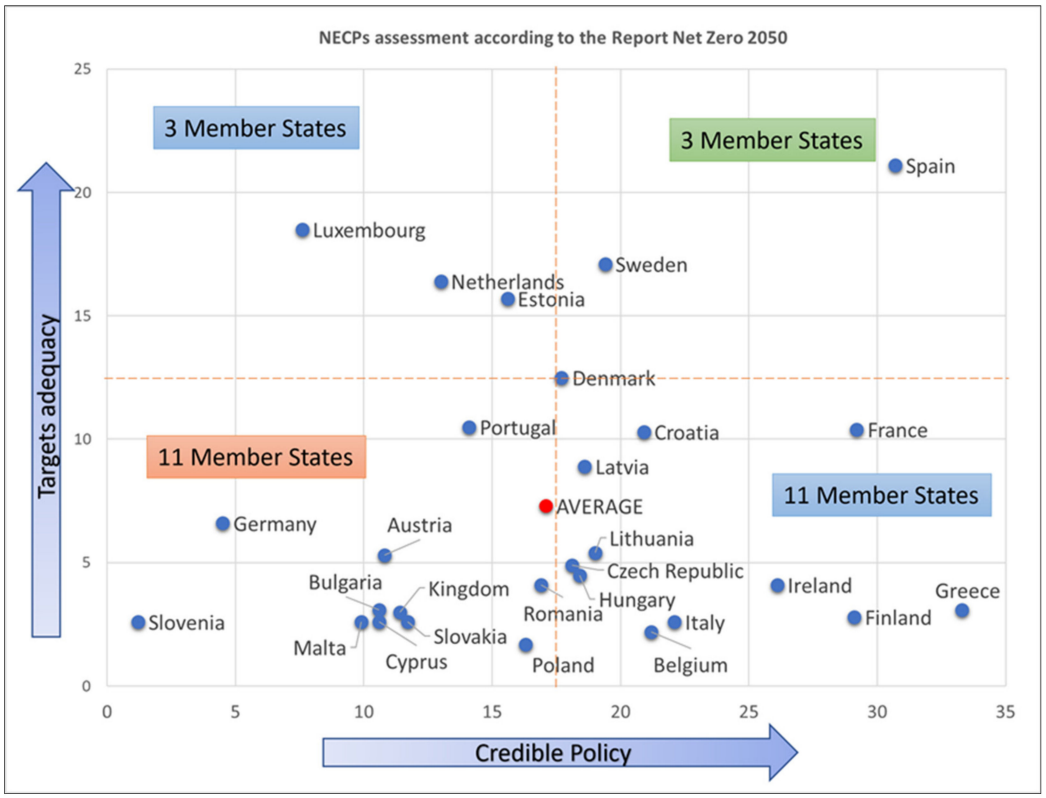

Figure 8. NECPs adequacy and policy details to accomplish Climate Regulation before the Green Deal by the study by Ecologic Institute (BE) in the series Net-zero 2050 Report (2019).

As a term of comparison in the evolution of the NECPs capacity to achieve the desired target, Figure 9 reports the Adequacy of the target versus the policy credibility according to EC assessment, similar to what was proposed in the NZR.

Figure 9 can be qualitatively compared to Figure 8; the assessment methodology of EC is different in metrics but not in the concept: in the NZR, NECPs present a concentration of countries below the targets adequacy (22 countries), and only half of them drafted credible policies to achieve low ambition targets. Figure 9 shows that most Member States are now more toward the implementation of credible policies, even with some different degree of completeness, and the ambition of the target is still partially addressed. However, 11 countries rise to at least a sufficient level of ambition.

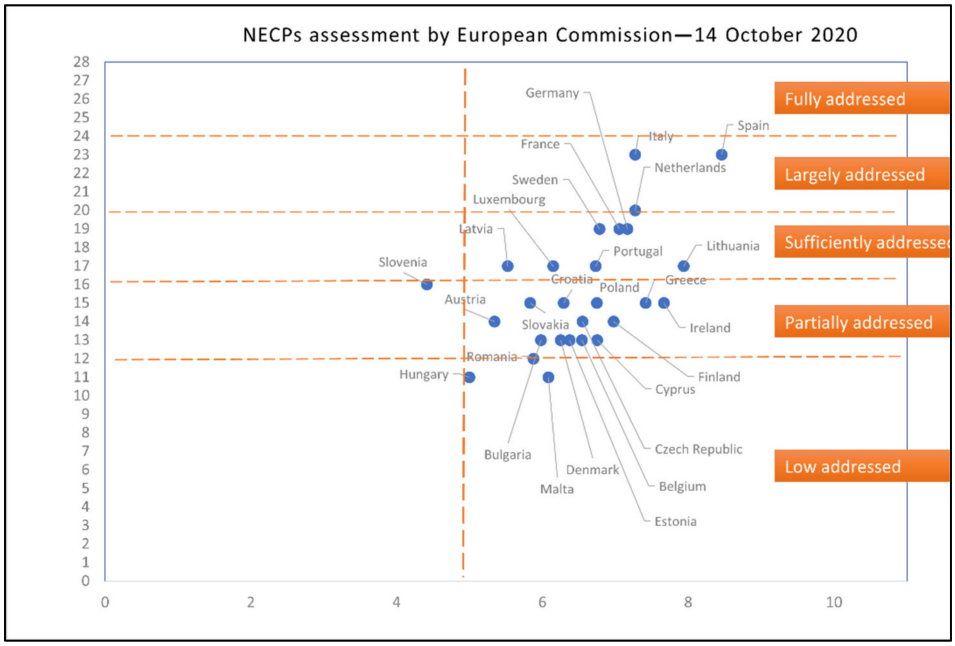

Figure 9. Final NECs assessment by EC based on SWD 2020.

3.2. LTS Assessment

Long-Term Strategies for the Member States must cover, with a perspective of at least 30 years, the following 10 objectives, already mentioned in the methods section, and here organized, as similarly for NECPs, by 4 groups (Table 9):

Table 9. EU27 main objectives to be achieved with the Long-Term Strategy.

Strategy	Targets	Investments	Policy
Overall goal LTS	GHG reductions	Estimated Investment	Adaptation Policies measures
Scenarios presented in the LTS	Renewable energy sources	Socio-Economic Impact of transition	Public Consultation
	Energy Efficiency		Legal status of LTS and targets

Member States need to draw up and submit national long-term renovation strategies, broken down to action at regional and local levels. At present (March 2022) one Member State has not yet presented its Long-Term Strategy.

The last available assessment of the Long-Term Strategy (EU27 carbon neutral by 2050) was received by 30 September 2021, and at that time 5 Member States had not submitted their LTS plans; Luxembourg presented the plan only in French, and the Summary table is not present; thus, the present study only assesses the plans received by September of the past year, excluding Luxembourg.

The assessment is based on the scale scoring in Table 3. The following Figures 10–13, show the scoring assignment for the Member States within each group.

Long-Term Strategy (Figure 10) shows the number of Member States that have fully or partially addressed the requirement to establish a clear goal of carbon neutrality by 2050 as well as the scenarios that should be followed to achieve the goal. While most of the countries have set a clear or a partially defined goal, scenarios are fully addressed only by 14 countries.

Concerning targets, Figure 11 reports the Member States assessment for the LTS scenarios: a GHG reduction target has been set by most; however, similarly to 2030 NECPs, the

implementation of targets about the share of renewables in total final energy consumption and "Energy Efficiency First" is still limited to half of the countries.

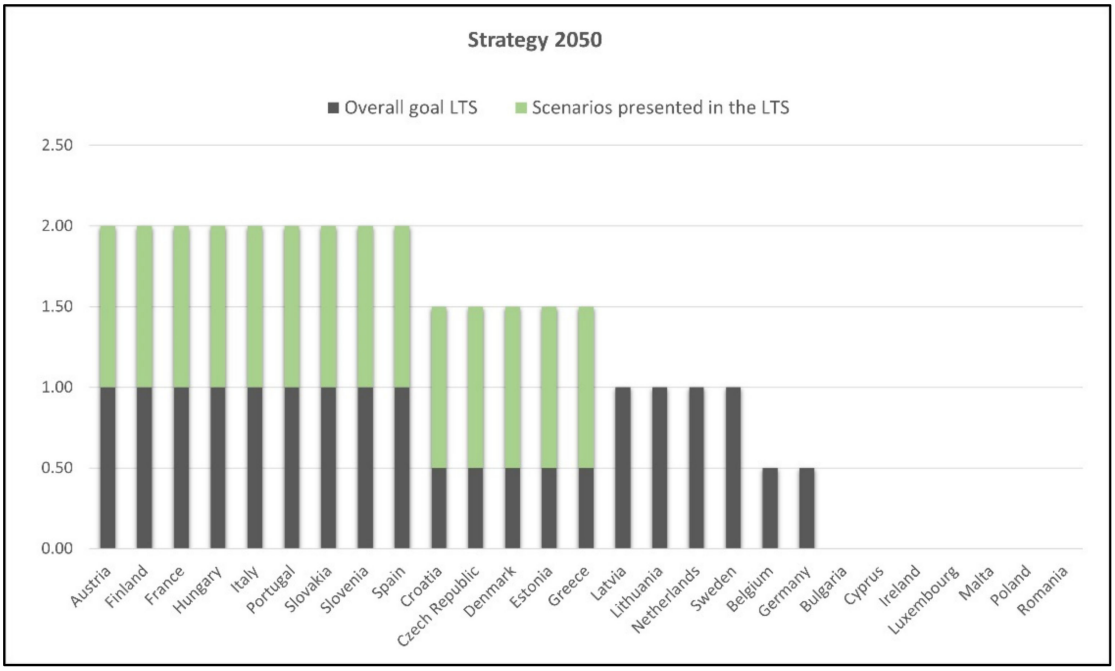

Figure 10. Member States strategy assessment: most countries have set an overall goal for the LTS, but not all are followed by scenarios.

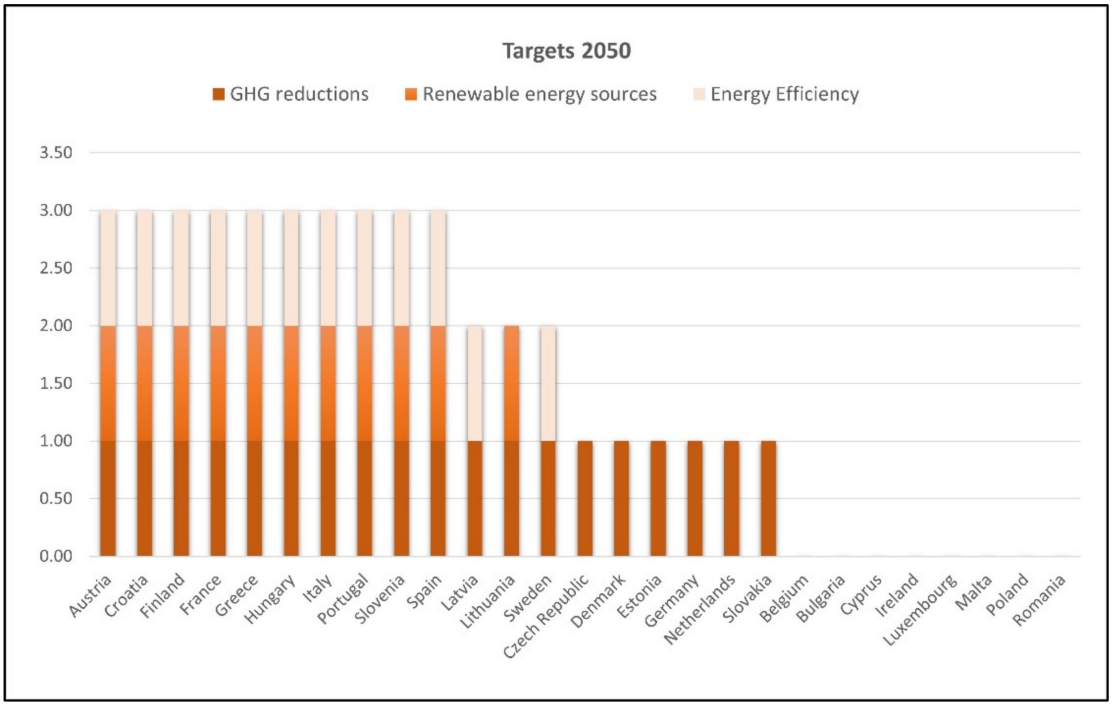

Figure 11. Long-Term Strategy targets; GHG reduction targets have been evaluated by 19 countries; renewable sharing is addressed only by 11 countries and energy efficiency measures by 12 countries.

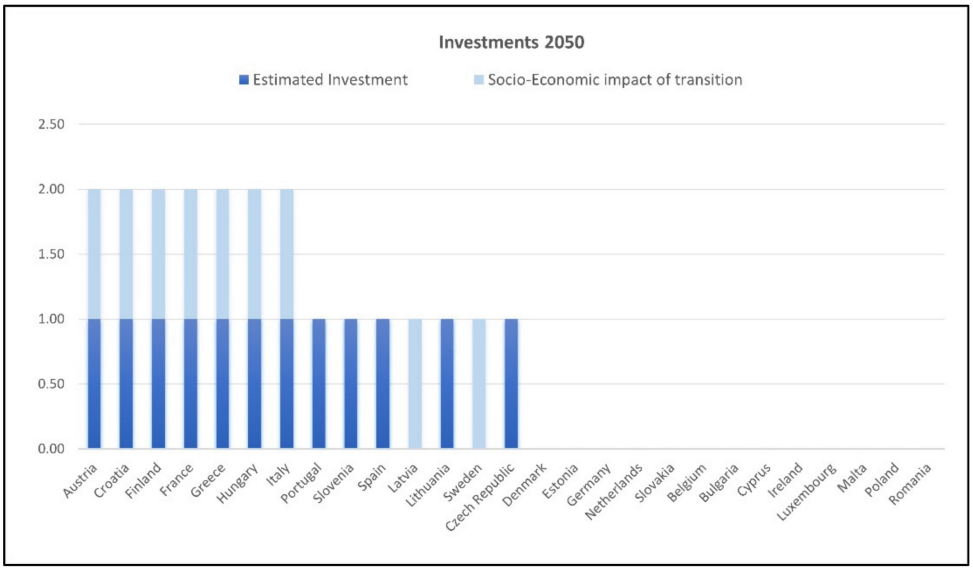

Figure 12. Less than half of the Member States drafted estimation on investment for the LTS; only 9 countries assessed a possible increase/decrease of GDP due to the climate neutrality goal.

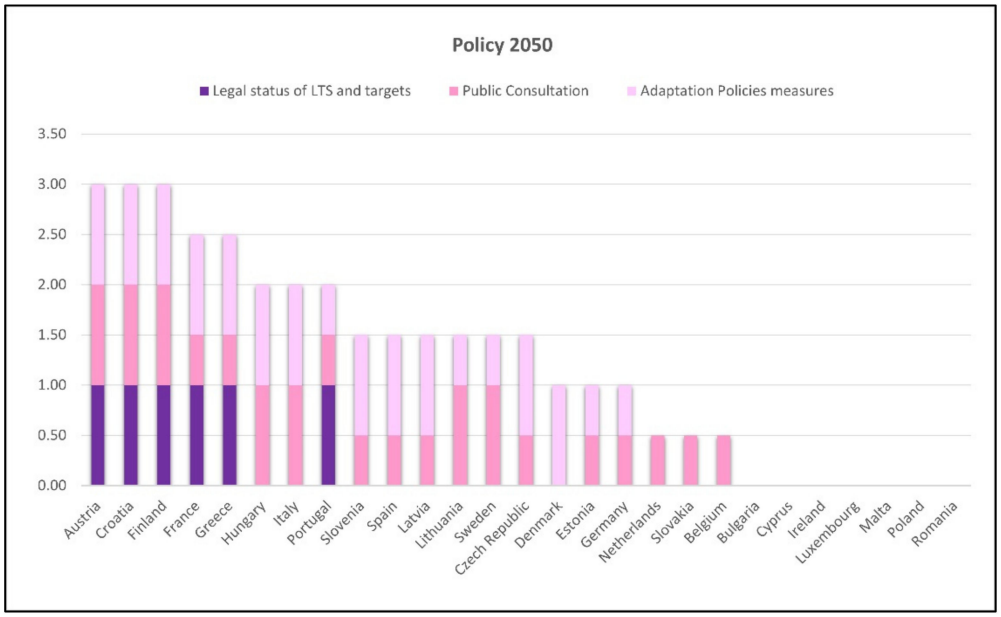

Figure 13. Long-Term Adaptation and policies measures are addressed by more than half of the Member States, and some are linked to national measures; public consultations have been partially addressed and the receipt of LTS in national plans is still very limited.

Investments (Figure 12) can include boosting measures to address the barriers to green finance [24], dedicating finance for decarbonization scenarios and public and private investment in specific economic sectors. Economic impact concerns both economic and employment benefits, an increase in energy provisioning's independency, limiting the use of fossil fuels and lowering emissions in urban areas. Figure 10 shows that investments and their likely impact on national GDP are still not addressed by most of the Member States.

Policy assessment (Figure 13) shows that 17 countries have partially or fully considered some adaptation policies in their plans, concerning environmental protection, the energy system, transport, mobility, etc., and the impact of climate change on regions. In the development of future policy, public consultation has been considered by 18 Countries

to collect views and opinions from the public on the technological and socio-economic pathways to be explored (Table 10).

Table 10. Objectives score for LTS as the contributions from each Member State to the EU27.

Objectives	Scores
Overall goal LTS	16.50
Scenarios presented in the LTS	14.00
GHG reductions	19.00
Renewable energy sources	11.00
Energy Efficiency	12.00
Estimated Investment	12.00
Socio-Economic impact of transition	9.00
Adaptation Policies measures	14.50
Public Consultation	13.00
Legal status of LTS and targets	6.00

As a final remark (Figure 14), Long-Term Strategies have been addressed, by the EU27, only partially. Countries have a clearer vision of the objectives, while the particular scenario the EU27 should follow to achieve those objectives is still lacking.

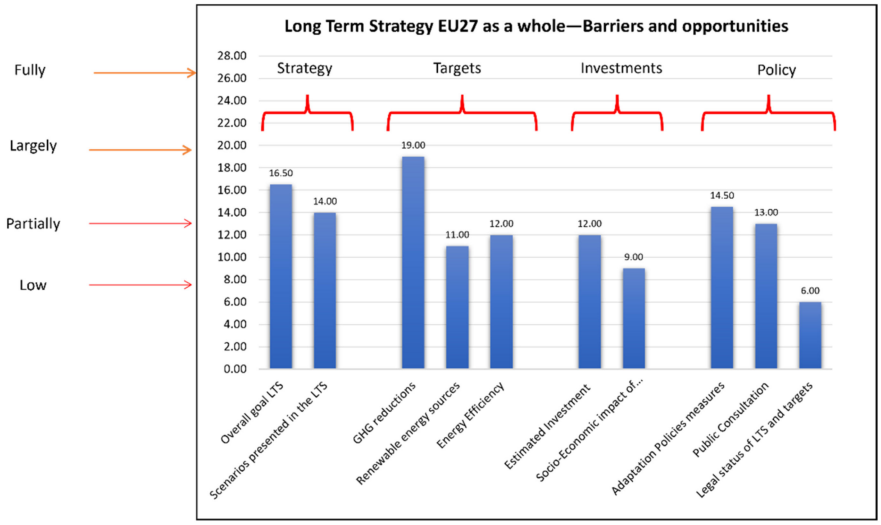

Figure 14. Long-Term Strategy EU27 as a whole: evaluation of the state of the art in accomplishing EU Long-Term Strategy to achieve carbon neutrality by 2050.

The degree of integration of the LTS policy in national policies is still low. Adaptation measures and public consultations have been addressed only partially.

It is worth mentioning that greater action/policy is set for a Long-Term Strategy in the building sector. Renovating both public and private buildings is an essential action and has been singled out in the European Green Deal as a key initiative to drive energy efficiency. Long-Term Renovation Strategies [25] (LTRS) have been submitted by 1 October 2021, and reviewed by the EU Commission on 6 December 2021 [35]. An assessment of the impact of building sector (and the other economic sectors) renovation impacts on decarbonization is beyond the scope of this present paper.

4. Conclusions

In the present study, an analysis of the short and long-term energy plans of the 27 European Union Member States was elaborated with a new methodology that allows for the quantification of the numerous categorical data present in the EC assessment reports about NECPs and LTS plans. In this way it is possible, for the first time, to measure and

graphically represent the effort of each Member State towards the achievement of the EU Green Deal and climate neutrality objectives. The methodology revealed is also suitable to be used in the next reporting period to track the Member States' evolution towards achieving compliance with EC commitments.

As for the results, the study shows the commitments promised by the Member States in the Draft NECPs (May 2019) were insufficient to put the EU on the right path to 2030 and 2050 decarbonization objectives. After the revision and the recommendations of the European Commission, Final NECPs (2020) show that, on average, the Member States have made a step forward in focusing on the targets committed by the Regulation and the more challenging Green Deal, although the actions/policies to achieve these targets are still only partially addressed. In particular, the study highlights the following points of attention as crucial topics that should be considered by the EC to strengthen the Member States' engagement in planning future actions:

1. Both in NECPs and LTS, targets are, on average, well-assessed, while the principle of Energy Efficiency First, one of the most important leverages to achieve the decarbonization is not sufficiently addressed. The Member States privilege investment in new technologies.
2. In NECPs, despite the EU27 Energy provisioning looking well-planned in terms of the energy market and Energy security, insufficient attention is given to Research and Development, even as countries establish clear targets in renewable share and other green production targets.
3. In NECPs, incentives and subsidies are, on average, addressed: however, many EU Member States still do not have a coal phase-out plan by 2030. Other countries are planning to replace coal with natural gas and are pushing for the use of EU funds to co-finance investments in natural gas infrastructure.
4. In NECPs the evaluation of the social impact of the transition is still only partially addressed.
5. In LTS, most of the planned objectives are still addressed only partially or low; as for the NECPs, the 2050 targets are generally clearly set, even the scenarios to achieve them. On the other side, financial estimations, the socio-economic impact of the transition and overall long-term policy are not yet sufficiently set.
6. Building sectors decarbonization has been prioritized among all the other actions.
7. The COVID−19 crisis unexpectedly brings the EU very close to reaching the 2020 energy efficiency targets. However, this is not the result of structural changes, and therefore it will lead to a rebound in energy consumption, which means that additional energy efficiency efforts and investments are needed.
8. The recent crisis in Ukraine will affect the energy market and the energy provision for EU27, especially for natural gas, although uncertainty remains as to how this will impact the net zero pathways.

It is important to highlight that NECPs and LTS objectives (a 55% cut in emissions in respect to 1990 and being carbon neutral by 2050) are the basis of the achievement of National Determined Contributions (NDCs) that the EU updated in 2020 for submission to the United Nations Framework Convention on Climate Change (UNFCCC) [36]. The 26th Conference of the Parties of the UNFCCC delivered the "Glasgow Climate Pact" [37] that amends the Paris Agreement's requirement for reviewing NDCs every five years, committing the countries to a revision of NDCs each year. This revision will not be effective if the implementation/revision of the NECPs and LTS plans are not carried out in parallel.

The EU has been at the forefront of international efforts to fight climate change. It played a crucial part in ratifying the Paris Agreement and should continue to show global leadership in striving for climate neutrality.

To achieve the Green Deal objectives with a "just transition", the European Commission allocated several funds to overcome difficulties and disparities, but those funds need to be reviewed in the light of the assessment in this paper to speed up the transition process.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su14084728/s1, EU 27 tables of NECPs and LTS scores. Supplementary data contains the results of the semantic scaling methodology for Member States arranged in alphabetical order. The set of tables ensure the transparency and reproducibility of the methods and results.

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