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Science policy frameworks for a post-pandemic green economic recovery

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ABSTRACT

As current production and consumption patterns exceed planetary boundaries, many leaders have stressed the need to adopt green economic stimulus policies in the aftermath of the COVID-19 pandemic. This paper provides an integrated multi-stakeholder framework to design an economic recovery strategy aligned with climate stabilisation objectives. We first employ quantitative energy and economic models, and then a multi-criteria decision process in which we engage social actors from government, enterprises and civil society. As a case study, we select green recovery measures that are relevant for a European Union country and assess their appropriateness with numerous criteria related to climate resilience and socio-economic sustainability. Results highlight trade-offs between immediate and long-run effects, economic and environmental objectives, and expert evidence and societal priorities. Importantly, we find that a 'return-to-normal' economic stimulus is environmentally unsustainable and economically inferior to most green recovery schemes.

1. Introduction

Since mid-2020, despite the persistence of the COVID-19 pandemic, the response of governments around the world has partly moved from the provision of immediate relief to the design and implementation of economic recovery measures for the short and medium term. Leaders of international organisations have stressed the importance of adopting green economic stimulus policies in line with the United Nations Sustainable Development Goals (UN SDGs) and the Paris agreement on Climate Change, as greener economies are more resilient to climate change, social unrest, and epidemics [1–4]. Global economic support for relief and recovery from the pandemic has risen to significant levels since spring 2020 – but as regards the conformity of such stimulus measures with climate compatible growth, the picture is mixed [5,6].

The lockdown measures to contain spread of the pandemic led to a serious economic downturn in Cyprus, with GDP contracting by 11.9% in the second quarter of 2020 [7]. As in other world regions, economic stimulus packages had to be designed for rapid implementation and to contribute to positive growth and employment impacts in the short term, keeping in mind long-term development and decarbonisation objectives, such as the EU's 2030 energy and climate goals and the envisioned carbon neutrality for 2050, as foreseen in the 'European Green Deal' [8].

In this paper we develop a novel integrated assessment framework for the design of an economic recovery strategy that could have promising impacts on climate resilience and socio-economic sustainability. This involves multi-criteria decision analysis, which incorporates both quantitative data derived from models and qualitative input provided by several stakeholders (Fig. 1). The adopted quantitative models are open-source and transparent, which allows for their rapid adaptation to the needs of policymakers in a specific country; the appropriateness of such models for rapid policy formulation has been demonstrated very recently [9]. The use of qualitative input is not only necessary because models cannot adequately simulate all possible impacts; it is also essential for increasing the likelihood of social acceptance of the proposed recovery interventions, by reducing dependence on knowledge silos of academic experts or policy makers. This is in line with the need for broader mobilization of society for the transition to sustainability [10]. Although we applied this approach in the case of Cyprus, an EU member state in the Eastern Mediterranean, the framework has general application, and the underlying tools and processes can be adopted in other national or regional contexts.

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This science-policy framework involves regular interaction with societal actors, which can help highlight the importance of thinking beyond purely short-term recovery measures and considering investments and reforms that may take time to materialise, but are essential for meeting medium- and long-term climate objectives [11]. A short-term recovery plan, no matter how green it is, cannot deliver the low-carbon transition by itself; it has to be complemented by structural reforms that can deliver environmental and economic benefits over the longer term [12]. Our approach highlighted this aspect to national stakeholders, some of whom were understandably interested in mitigating the immediate impacts of the pandemic and paid less attention to long-term green reforms. Based on quantitative evidence which is shown in this paper, we also emphasised the mediocre performance of a 'return-to-normal' economic stimulus, not only in environmental but also in economic terms. To encourage ownership of the measures by national decision makers we built on policies and measures that are largely based on existing national plans so that stakeholders are familiar with such interventions. This increases the likelihood for adoption of these measures in the national recovery strategy.

This novel combination of a) building on familiar national plans, b) employing open-source models that can be rapidly adapted to national particularities, c) comparing the performance of green versus business-*as*-usual stimulus plans and d) obtaining immediate qualitative input from national stakeholders can serve as a model for many countries around the world, which have requested assistance from international organisations on designing recovery packages during late 2020 and early 2021.

Section 2 of the paper describes the main stages of this approach, the recovery measures that were considered, and the sustainability criteria used for assessing these measures. Section 3 presents the results of the energy and economic models employed, while it also provides an overview of the multi-criteria assessment, which makes use of input from a targeted group of stakeholders. Finally, Section 4 outlines the lessons learnt from this study and their relevance for science-policy interactions in other national contexts.

2. Methods

2.1. Workflow

Post-pandemic stimulus packages have to promote short-term economic growth without compromising long-term energy and climate goals. To address these multiple requirements, it was necessary to assess promising green economic recovery measures that had already been identified in the public discourse.

We started from existing plans announced by the Finance Minister in May 2020 as well as from measures included in the National Energy and Climate Plan (NECP) submitted to the European Commission in January 2020 [13]. Similarly, if the framework is applied in a non-EU country, the approach might begin with a breakdown of the measures included in a country's Nationally Determined Contribution (NDC) to the UN Framework Convention on Climate Change. In summary, the approach involves proposing interventions which expand measures already announced or planned by national authorities; receiving feedback from stakeholders to obtain a first reality check; assessing measures with proper criteria that account for multiple sustainability objectives in the short (up to 2022) and long term (up to 2030); and prioritising measures on the basis of this assessment, considering budget availability.

Above all, it was important to ensure active participation of decision makers in the process, by using transparent workflows. This enables Ministry officers to provide input at various stages of this work, and ensures overall process accountability. In so doing we tend towards U4RIA guidelines. U4RIA is an acronym for Ubuntu,[1] Retrievability, Reusability, Repeatability, Re-constructability, Interoperability and Auditability. It aims to further good governance and sound scientific principles to energy modelling for policy support [14].

Specifically, the workflow consisted of the following stages:

1. *Screening and preliminary assessment of potential green stimulus measures.* In April 2020 we published a policy brief, alerting policymakers on the need to ensure that economic stimulus measures would enable the green transition [15]. We identified a first list of measures that could be implemented quickly, with positive employment and environmental impacts.
2. *Dissemination of the list of measures and stakeholders' feedback.* The initial list of green recovery measures was circulated to Ministries of Finance, Environment, Energy and Transport, European Commission officials, NGO representatives and academics. Stakeholders focused on the need to ensure low administrative burden to allow fast implementation, and the importance of aligning the proposals with measures announced by the national government.
3. *Interaction with national business associations.* In mid-May 2020, after the first wave of the pandemic had been contained and public discussions focused on the 'return to normality', the national Federation of Employers and Industrialists (OEB) set up a working group on the green restart of the economy, in which we participated. OEB used our proposals as a starting point and supplemented them with additional measures targeted to enterprises.
4. *Enriched list of stimulus measures.* Based on the discussions in OEB's working group, a revised list of green stimulus measures was sent to the Finance Minister of Cyprus in mid-June 2020. Three types of measures were included:
   - Those which complemented general stimulus measures already announced by the Finance Minister;
   - Measures included in the official NECP;
   - New measures that could be implemented quickly, including institutional reforms that could facilitate the achievement of long-term climate neutrality.

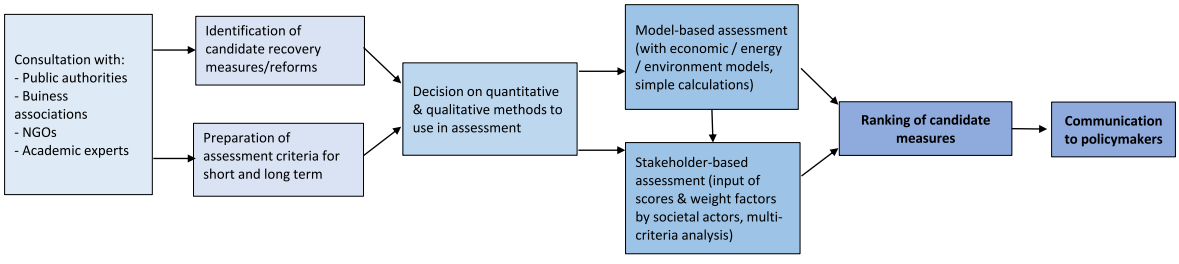

Fig. 1. Approach to designing and assessing a green economic recovery strategy.

[1] Ubuntu, meaning 'I am because you are' is used to refer to the need for engagement and accountability with the relevant stakeholders and the inherent interdependency with the researchers.

Thirteen interventions were thus identified (Table 1). Details about each measure are provided in Appendix A.

Table 1
Green recovery measures considered in this paper.

Name of measure	Sector	Investment cost 2020–2022 (M€)	Investment cost 2020–2030 (M€)	of which from public funds
M1. Immediate launch of grants for energy renovations of buildings from unused budget of 2020–21	Buildings	30	30	50%
M2. New grant scheme for energy renovations of existing buildings, 2021-27	Buildings	70	140	50%
M3. Grants for energy renovations of buildings under construction for upgrade to Near-Zero Energy Buildings	Buildings	70	70	50%
M4. Installation of smart electricity meters	Electricity	35	55	100%
M5. Virtual net billing for encouragement of photovoltaic installations by enterprises	Electricity	29	136	0%
M6. Subsidy to loans of businesses certified with an environmental management system	Industry	2	2	100%
M7. Business4Climate scheme - grants to enterprises with a verified low-carbon action plan up to 2030	Industry	5	10	30%
M8. Implementation of existing Sustainable Urban Mobility Plans (SUMP)	Transport	80	100	100%
M9. Construction of tram in the capital city of Nicosia	Transport	0	225	100%
M10. Scrappage scheme for old cars to be replaced with battery electric vehicles	Transport	12	12	30%
M11. Replacement of streetlights in municipalities and villages with energy efficient lighting	Electricity	45	45	100%
M12. Tree planting along urban and intercity roads	Nature	17	85	100%
M13. Fiscally neutral carbon taxation for economic sectors out of the EU Emissions Trading System	Horizontal	0.5	0.5	100%
Total		**395**	**911**	

Note: Costs are expressed in million Euros at constant prices of year 2020.

5. *Preparing a list of criteria for the assessment of recovery measures.* A list of sustainability criteria was created, using as a starting point a comprehensive checklist developed by the World Bank [16] especially for post-COVID19 economic stimulus interventions. Some of those criteria were less relevant for the measures considered here and were omitted. Two more criteria were added: the technical and/or financial viability of each measure, and its anticipated social acceptance, related to its affordability. Appendix B provides the final list of criteria.
6. *Identifying the appropriate methodology to assess impacts.* For each measure, the energy, climate, and employment impact had to be assessed through simple calculations or with the aid of models available for Cyprus. For some measures, such as energy renovations in buildings, detailed building stock models were not available, so the analysis had to rely on simple calculations. For other measures, such as the promotion of sustainable modes of transport, an OSeMOSYS model of the Cypriot energy system provided short- and long-term projections on energy consumption and emissions of greenhouse gases and air pollutants. Economic impacts can sometimes be modelled through the available input-output model of the Cypriot economy, but others require a qualitative assessment based, for instance, on the percentage of domestic capital and labour inputs for the considered activity. Taliotis et al. [17] describe the energy and economic models in more detail. Since these models are open-source and have been used for preparing the NECP, national Ministries have full access to them and can conduct follow-up analyses if needed.
7. *Assignment of scores and weights for each sustainability criterion.* After the model-based energy and economic assessment of the measures was completed, qualitative assessments followed for the rest of the criteria. Stakeholder input was sought, and a specific workshop was organised with representatives of different governmental departments, the private sector, and NGOs. Each stakeholder provided a score of each recovery measure by criterion and a weight for all criteria.
8. *Prioritisation of measures.* Stakeholder data were processed and, along with model-based results, provided a final ranking of the proposed interventions. These were communicated to all decision makers (DMs). Governmental authorities are able to use these to prioritise recovery measures.

2.2. Quantitative analysis

2.2.1. Energy modelling

The assessment of the effect of green interventions on energy use and air emissions was carried out with OSeMOSYS, a long-term cost-optimisation energy systems model [18]. Some of the input to OSeMOSYS is provided by a separate energy forecast model [19], which projects final energy consumption across the economy and the related energy expenditures of households and businesses. The application of OSeMOSYS for the energy system of Cyprus is described in detail in previous studies [17,20].

For this specific study, OSeMOSYS was used to quantify impacts related to the implementation of existing Sustainable Urban Mobility Plans (SUMPs) (M8), the construction of the tram line in the capital city of Nicosia (M9), the scrappage scheme for old cars to be replaced with battery electric vehicles (M10), and the gradual implementation of a fiscally neutral carbon taxation system for sectors that do not fall within the EU Emissions Trading System (ETS) (M13). The first two of these measures are included in the country's National Energy and Climate Plan [13], while the latter two interventions have already been under consideration by the government. The model output focused only on benefits related to energy savings and carbon emission reductions; improvements in air quality and congestion, which are essential benefits of sustainable mobility measures, were not considered explicitly but were included in a qualitative manner in the criterion 'other environmental impacts'.

Implementation of SUMPs entails an effort to achieve a considerable shift away from private vehicles to sustainable modes of transport. The techno-economic characteristics for each technology option in these modes is available in the existing base literature [21]. The development of the tram line in Nicosia, which is planned to come into operation in 2028, is closely related to SUMPs; that project will further enable the adoption of sustainable mobility and is assumed to reduce the annual mileage of private passenger cars and motorcycles by 540 and 16 million vehicle-kilometres respectively. According to the feasibility study conducted by national authorities, the tram line will have an upfront cost of approximately €225 million and annual operation and maintenance costs of €12 million [22].

The third measure that relates to the transport sector is the scrappage of old passenger vehicles and their replacement with battery electric vehicles. For a maximum replacement rate of 200 vehicles per year with a grant of €5000 per vehicle, this measure will require public funds of €1 million annually. Overall, it is assumed that 400 vehicles will be replaced through this scheme. Finally, a carbon tax on fuels for sectors that do not fall within the EU ETS is assumed to be implemented gradually and reach €120 per tonne of CO_2 by 2025. This will encourage adoption of energy efficiency measures and increase the attractiveness of low-carbon technologies, such as heat pumps in the heating and cooling sector and electric vehicles in the transport sector.

2.2.2. Economic modelling

Input-Output (IO) analysis is a quantitative technique for studying the interdependence of production sectors in an economy over a stated time period [23,24]. Here we applied a continuous demand-driven IO model with disequilibrium adjustment processes to assess the economy-wide effects of the selected energy-related economic recovery measures. Projected annual expenditures, including capital investments and operation and maintenance costs, from the OSeMOSYS model are introduced to the IO model to reflect changes in the investment demand of economic sectors as a result of each of the measures. Expenditures are classified in seven categories: industrial equipment, power generation technologies, electricity storage technologies, gas infrastructure, public transport, private transport, and buildings (including energy efficiency measures, heat pumps, solar water heaters etc.). Projected annual energy consumption expenditure of households is introduced to the IO model to estimate the multiplier effect of changes in private consumption. Tables in Appendix C present the distribution of annual spending associated with investments and private consumption by sector of economic activity for each recovery measure. The shares of spending for the development and operation of the recovery measures to the individual economic sectors have been allocated based on information obtained from relevant literature [25,26]. Taliotis et al. [17] describe in detail the assumptions behind the distribution of spending for each measure.

The initial static equilibrium conditions of the IO model, which serve as the reference case, are based on the latest available national symmetric IO table of Cyprus for the year 2016. The national table, which includes 65 sectors of economic activity, was aggregated into 20 economic sectors and is presented in Appendix C. The demand growth rates for the economic sectors are defined based on the GDP projections for the period up to 2030, including the impact of COVID-19 pandemic, and were obtained from the Ministry of Finance. For 2020 we assumed a decline in the growth of the Cypriot economy (−7.4%) across all economic sectors, and for 2021 a strong economy-wide recovery (+6.1%). From 2023 onwards, growth rates return to usual levels following the official national macroeconomic outlook. Some of the recovery measures listed in Table 1 involve energy savings and hence induce a decrease in private consumption for energy, traded products, and services. We assumed that this reduction of spending, after accounting for household savings (we assumed a household saving rate of 2.4% of disposable income in Cyprus, in line with Eurostat [27]), will return to the economy and induce a rise in consumer demand for goods and services in line with the current consumption expenditure of Cypriot households [28].

Finally, apart from the thirteen selected green recovery measures, we explored the macroeconomic effects of a counterfactual scenario, which would be to provide uniform economy-wide demand stimulus. In this scenario, we aggregated the capital investments of all measures, amounting to 395 million Euros'2020 up to 2022 as shown in Table 1, and reallocated them in the economy according to the current sectoral shares of final demand.

2.3. Multi-criteria assessment

2.3.1. Overview of the assessment framework

Multi-criteria decision analysis (MCDA) has been developed to support DMs, especially when facing decisions involving multiple and potentially competing objectives [29]. In the last decades, several methods have been developed for many types of decision problems. MCDA techniques have been widely applied in a variety of fields, including energy and environment [30–34]. Two of the most common methods used are the Analytical Hierarchy Process (AHP) method and the Preference Ranking Organisation Method for Enriching Evaluation (PROMETHEE) [35,36]. There are several examples of applications of AHP and PROMETHEE in the fields of energy planning, selection of energy projects, and sustainable supply chains [37–39]. PROMETHEE has also been used in the development and evaluation of scenarios for energy planning [40,41] and for evaluating market opportunities for renewables [42].

AHP and PROMETHEE can be combined, as shown by several studies [43–45]. AHP can be used to produce the weights of each criterion for each DM, which would be used as an input for applying PROMETHEE to produce the ranking of the actions. A similar framework has been developed in Matlab® for this paper, using a PROMETHEE Group Decision Support System (GDSS) approach.

Appendix D provides technical information about the application of these methods. In summary, AHP is a pairwise comparison method which uses a ratio scale that does not require any units. DMs express their preferences for one alternative over another one, using a 1–9 scale, which is assumed to offer the appropriate flexibility. In the framework of this study the 23 criteria shown in Appendix B have been divided into two broad categories of short- and long-term impacts and further subdivided into two subcategories, namely: (i) environmental criteria, and (ii) economic/social criteria.

For the evaluation and ranking of the alternatives the PROMETHEE method has been applied. The independent experts were asked to provide a score of each alternative recovery measure (or action according to PROMETHEE terminology) for each criterion in a typical 1–5 scale ranging from 'very low' to 'very high' impact. As several DMs provided input, the PROMETHEE GDSS was then implemented to combine the scores of individual DMs and produce a global evaluation that leads to the final ranking of measures.

2.3.2. Stakeholder input

A variety of stakeholders were invited to act as DMs and provide input. The group of DMs consisted of ten stakeholders: three economic planning officers from the Finance Ministry, one tax officer from the Finance Ministry, one officer from the Ministry of Energy, one officer from the Ministry of Transport, one from an energy NGO, one from an environmental NGO, and two from the national Federation of Employers representing the private sector. At the workshopthe participants were informed in detail about the list of recovery measures and the evaluation criteria, and were then provided with the respective tables to fill in (Appendix E). Weighting of the different criteria according to each DM's preferences, in line with the AHP method, was carried out through a piecewise comparison between each criterion. All input required for the application of the AHP method was checked for consistency. In all cases, the consistency ratio was calculated and was found to lie below the threshold of 10%, so that the input of all DMs was considered to be

consistent.

Next, the PROMETHEE II method was applied, in which each DM evaluated the performance of all green interventions with a score in the scale 1–5, indicating an evaluation ranging from 'very low' to 'very high'. Scores for each recovery measure by criterion, in line with this method, were provided by each stakeholder. It should be noted that the scores for four criteria (energy savings, carbon emission savings, economic multiplier, and new jobs created) have been calculated through simulations with the relevant aforementioned models, therefore stakeholders could not change these scores.

Before arriving at the final results, it was necessary to calculate the net flow from the input of each stakeholder. The final step was the application of PROMETHEE GDSS to calculate the global ranking of all measures, assuming that each one of the ten stakeholders has equal weight. Obviously, the ranking of alternatives is affected by both the weights assigned by each DM and their respective scoring by measure and criterion.

2.3.3. Sensitivity analysis

The PROMETHEE method provides the ranking among a set of alternatives by considering the preferences of individual DMs, which is a result of their respective evaluations and weights. Considering that the weights have a significant impact on the final ranking, four alternative scenarios were examined. First, an analysis was carried out where the values assigned to the weights for each criterion varied for each DM (scenario 1). Given the large size of this problem, this analysis was carried out by implementing an iterative approach where the weights follow a uniform distribution in the interval [0,1] in 1000 iterations. Second, a similar approach was used where the values assigned to the weights for each DM in the PROMETHEE GDSS were changing, in order to examine the impact each individual DM has on the final ranking (scenario 2). The results are evaluated via a "robustness index", which shows how many times the measures ranked as top five are repeated. Third, only the input from the six government officials of our sample is considered to produce the ranking of measures (scenario 3). Fourth, the input from the four economists of the sample was used to produce an alternative ranking (scenario 4).

The aim of the first two sensitivity cases (scenarios 1 and 2) was to examine how sensitive the results are to a change in the weights of the criteria. The top 5 measures had high robustness indices and a very high probability of being ranked as top 5 even when the weights of the DMs change. For instance, the first two measures of the original ranking (M13 and M5) have a probability of 98% and 99.2% of being in the top five, respectively. Scenario 3 results are the same with those of the base GDSS (i.e. all stakeholders), although with a different ranking. However, results are very different in Scenario 4. In this scenario, M7 (grants to enterprises) ranks first instead of M13 (carbon taxation), which now ranks sixth. Also, two other measures appear in the top five list (M6: subsidies to business loans with an environmental management system; M3: grants for energy renovations of buildings to upgrade to NZEB).

3. Results and discussion

After extensive deliberations with stakeholders from the public and private sector since the outbreak of the pandemic, we arrived at thirteen recovery measures to evaluate further. We used a wide array of sustainability criteria for assessing these thirteen interventions, adapted from a comprehensive checklist that was developed by the World Bank [16]. As the EU decided in 2019 to explicitly include the seventeen UN SDGs in its regular macroeconomic monitoring procedure, and due to the universality of SDGs [46], Appendix B also includes an indication of the SDGs addressed by each sustainability criterion used in this analysis.

3.1. Energy and economy model results

Some of the quantitative criteria – those related to impacts of green measures on energy use, carbon dioxide emissions, economic output, and jobs – were evaluated through specialised models that had been already used for national impact assessments and were known to public authorities. The energy model provided projections for energy and carbon emission savings per million of Euros invested in each measure. According to model results, some of the best-performing measures in the short-term are also the preferred ones for the longer term (up to 2030); these are carbon taxation (a regulatory measure with very low implementation costs), virtual net billing (which is also regulatory and will enable a faster deployment of decentralised solar power generation), and implementation of urban mobility plans. In the short run, measures on energy efficiency upgrades also have good carbon abatement potential per unit of investment.

To simulate the impact of each recovery measure on economic growth and employment, an economic input-output model was used. The impact of a policy depends on how much investments in a sector affect demand for goods/services in other sectors, what part of intermediate inputs of a sector takes place in the country, which production activities are displaced, and how labour-intensive are the sectors affected by new investments, compared to that of displaced activities. Note that the reduction of household consumption in response to energy efficiency improvements is returned in the economy and further respent through a rise in consumer demand for goods and services. Fig. 2 illustrates the differences in economic effects versus (a) employment and (b) environmental effects of the modelled interventions. The impact is relatively higher in the short run due to the front loaded allocation of investment expenditures in 2021–22, both because this is what a recovery plan focuses on, and because a strong economy-wide rebound was assumed for these two years.

It is interesting to compare Fig. 2a with Fig. 2b, in order to assess the performance of measures across the key economic and environmental criteria. Even though several measures, such as car scrappage, installation of smart meters and energy renovations, perform quite well in terms of economic multiplier and employment, as indicated in the top right corner of Fig. 2a, these same measures do not lead to high carbon dioxide emission reductions. In fact, no measure appears in the top right quadrant of Fig. 2b, despite the emission reduction effectiveness of some of the measures focusing on improving efficiency. This might be an indication that the pool of measures does not include individual measures that manage to perform ideally across all three of these categories (i.e. economic output, employment, emission reductions), which makes the selection of measures with diverse benefits even more imperative.

Results confirm once more the conclusion that Barbier [12], Popp et al. [47], and Strand and Toman [11] have drawn on the basis of ex-post assessments around the world: measures performing best in the short run are partly different from those with the largest positive effect in the longer term. With regard to economic output generation, in the short-run measures M4 and M5 (installation of smart electricity meters and virtual net billing respectively) create the highest economy-wide effects relative to the reference scenario; for every million Euro (M€) invested for these interventions, the total output of the economy increases by 1.45 M€ and 1.44 M€ respectively in 2022–23. Two measures that could boost short-term output, M9 and M12, are not included – M9 because the construction of the tram line is expected to start after 2023, and M12 because tree planting has not been simulated with the IO model due to lack of data. In the long run, virtual net billing (M5) creates the highest economy-wide effects.

The impacts on employment are similar but not identical to the effect on economic output. In the short run, virtual net billing and smart meters create the highest positive effects on national employment; for every million Euro invested in either measure, about 14 new jobs are created throughout the economy. In the long-run, the virtual net billing measure still creates the highest economy-wide employment effects. On the contrary, sustainable mobility interventions M8 and M9 do not perform well in terms of employment generation, thanks to their success to shift mobility from private cars to public transport; this causes household

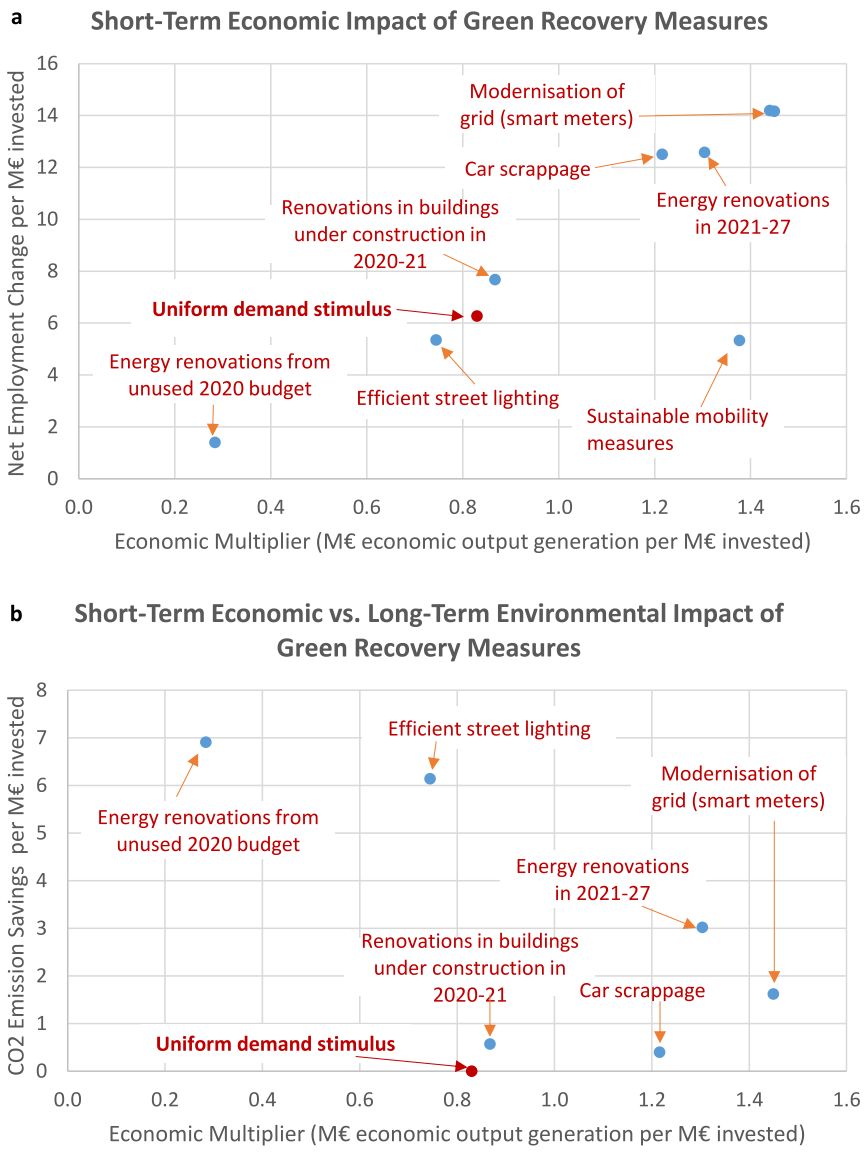

Fig. 2. Relationship between short-term impact of measures on economic output and employment (a) and between short-term effect on economic output vs. long-term effect on carbon emission savings (b).

spending for fuel and car purchases as well as for car maintenance to drop considerably, and the affected economic activities (imports of fuels and vehicles) which are labour-intensive seem to have a negative impact on the overall employment.

However, such model-based seemingly undesired effects of energy efficiency measures have to be treated with caution. They should not be interpreted as suggesting to avoid energy efficiency investments that improve the economy-wide productivity of energy use. A feature of input-output economic models is the assumption of fixed technical coefficients: the combinations of inputs are employed in fixed proportions. This assumption implies that there is no substitution among the inputs and no technological progress, which is plausible when immediate policy impacts are simulated, but becomes less realistic when the impacts over a longer time horizon are modelled. The effect of the changing technical coefficients - due to changes in production technologies - on GDP, employment and CO_2 emissions using either modelling techniques or expert judgements [48,49] can be pursued in future enhancements of this work. To the extent that the reduced economic output and employment in sectors such as trade of vehicles and fuels is compensated through re-training of workers and re-orientation of business activities, negative economic impacts of sustainable mobility can be overcome. More broadly, the ability of an economy to transform itself and use the resources saved to grow new sectors, or to divert saved resources to export-oriented activities as a result of increased business competitiveness, will depend on factors like people's skills, availability of financing and policy decisions – aspects that are insufficiently accounted for by this kind of economic models.

It should also be noted that the economic model does not distinguish between employment categories, so our approach cannot include the separate impact on low-skilled and high-skilled workers, which would be important for evaluating the effect of each intervention on long-term growth prospects. Such considerations are important in view of the findings of studies that examined stimulus measures applied after the 2008–2009 economic downturn, which highlight the importance of observing differences in skills in order to properly compare alternative policies [50]. These are aspects that merit further investigation. As such, a disaggregation of employment IO multipliers can be pursued in the future to better portray the effects of measures on low- and high-skilled

employment and subsequently on overall long-term growth. Moreover, job calculations do not account for the possibility that supply of skills in some sectors may not suffice to meet growing demand. For example, a construction boom due to energy renovations may be limited by a lack of skilled technicians in the country, at a time where a 'renovation wave' in buildings is foreseen across Europe. Therefore, before deciding on the extent of implementation of a recovery measure, a skill mismatch analysis would be needed to ensure that human resources are available for realising this intervention.

It is particularly interesting to observe the results of the counterfactual scenario, which assumes a 'return-to-normal' economic stimulus, where all recovery funds are allocated uniformly to households and businesses, and consumption continues as before. As indicated by a red dot in Fig. 2, a business-*as*-usual economic recovery is clearly not the preferable option; with an economic multiplier of just 0.83 it performs better than only two out of all the green measures. It also has a mediocre effect in terms of employment generation, with 6.3 new jobs per M€, whereas four green measures have more than double job benefits. This clearly indicates that a uniform demand stimulus is far from the most effective strategy for increasing employment in the short term. Such a finding, which has been explored by very few studies so far, is confirmed by Pollitt [51] for some major EU economies (through a macro-econometric model) and by the IMF [52] for the global economy (through a computable general equilibrium model).

3.2. Multi-criteria assessment results

The transition to sustainability requires implementation of ambitious but actionable measures, and stakeholder participation for co-developing a green stimulus plan is crucial. Therefore, a variety of stakeholders were invited to provide input for this assessment. They were selected in order to be representative of public authorities, businesses, and civil society, and participated in a dedicated workshop, held in October 2020. Specifically, ten stakeholders participated in the evaluation: one representative from the Ministry of Transport, one representative from the Ministry of Energy, two representatives from the Ministry of Finance, two representatives from the Directorate General Growth, one representative from an environmental NGO, one representative from an NGO promoting sustainable energy, one partner from the National Association of Employers and Industrialists, and one partner from academia. There, participants were presented with the recovery measures and the evaluation criteria and were then provided with the respective tables to fill in, applying the adopted multi-criteria methods.

Preferences of workshop participants varied significantly by criterion, highlighting the different priorities of each stakeholder, as indicated in Appendix F. For example, representatives of private enterprises valued short-term criteria more strongly than long-term ones, in contrast to other stakeholders. On the other hand, governmental stakeholders provided a higher weight to long-term environmental criteria compared to short-term ones. Overall, most decision makers assigned a higher importance to the long-than to the short-term, whereas there was no consistent preference to environmental versus economic/social criteria.

Fig. 3 displays intermediate results of the evaluation, before applying the final weighting of all criteria. It illustrates the relative strengths and weaknesses of each measure in terms of short- or long-term economic and environmental performance, as perceived by the participating stakeholders. For instance, the carbon tax reform (measure M13) received a high score for its environmental performance in both the short- and the long-term, and actions related to sustainable mobility (M8 and M9) also had a good score on long-term environmental performance. Conversely, measures M5, M6 and M7, which mainly target businesses, were assigned by participants the highest scores regarding long-term economic effectiveness. Visualization of this variability in the perceived economic and environmental effectiveness of the various measures highlights the contrast between the respective criteria and could provide useful insights before policy implementation.

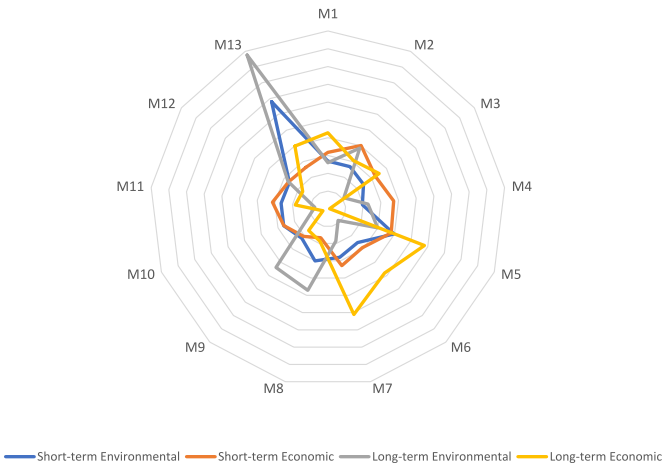

Fig. 3. Evaluation of recovery measures based on the average input of all stakeholders.

After weighting the scores for all groups of criteria (environmental and socio-economic, short- and long-term), the final ranking shows that the best green recovery intervention is considered to be the fiscally neutral carbon tax reform (M13) (Table 2). This measure had the best results in terms of energy savings and carbon savings for the short- and long-term, which were calculated using quantitative models, but received also high evaluations from the stakeholders in several criteria – it ranked first in the individual ranking of five out of ten stakeholders. In addition, stakeholders valued measures M5, M2 and M7 (implementation of virtual net billing, energy renovations of buildings and grants to reduce the carbon footprint of enterprises) as the next most important for the sustainable development of Cyprus.

These results offer interesting insights when compared to evaluations performed informally by some of the authors, who applied a simple assessment approach to obtain a rapid overview of the preferred policies. Although the expert view of some of the authors had considered long-term infrastructure modernisation and decarbonisation interventions as important priorities, those were not among the preferred measures of stakeholders. For example, the only nature-based measure (M12 – tree planting) and the two sustainable mobility measures (M8 and M9) rank average or below-average in stakeholder preferences; this may be attributed to concerns by some stakeholders, which were orally communicated during the workshop, that these measures are unrealistic, too costly, or can only have limited effects. Another reason may be that most stakeholders considered the period to 2030 as 'long-term' and

Table 2
Ranking of recovery measures in descending order through multi-criteria analysis and stakeholder input.

Measure no.	Measure description
M13	Fiscally neutral carbon tax reform for sectors out of the EU Emissions Trading System
M5	Virtual net billing for encouragement of photovoltaic installations
M2	New grants for energy renovations of existing buildings, 2021-27
M7	Grants to enterprises with verified low-carbon action plan up to 2030
M1	Immediate launch of grants for energy renovations from unused budget of 2020–21
M8	Sustainable Urban Mobility Plans
M6	Subsidy to loans of green businesses
M9	Construction of tram in the capital city of Nicosia
M12	Tree planting
M3	Energy renovations of buildings under construction within 2020
M4	Installation of smart electricity meters
M11	Energy efficient street lighting
M10	Replacement of old cars with electric vehicles

left 2050 out of sight. However, to achieve carbon neutrality by 2050, ambitious measures are necessary already now, in order to allow time for technology penetration and behavioural changes [53,54]. Nonetheless, such discrepancies are not surprising; it has been recognised in the literature that stakeholder preferences diverge from those of experts [39].

Even when they contradict modelling results and expert opinions, these views need to be taken seriously, considering the direct experience of stakeholders and decision-makers. Some measures may have lower social acceptance than experts believe, and may require more in-depth work to take into account stakeholders' concerns – for example, by considering more carefully the risks of some measures to social equity and through proper information and communication campaigns to target audiences and the broader public.

At the same time, it is interesting that a seemingly unpopular measure (carbon taxation, even if framed as fiscally neutral) received the top score among recovery measures. In view of the extensive discussions about the social acceptance of such pricing schemes worldwide [55,56], this seems to be a surprising but also encouraging result, as carbon pricing is widely considered by economists as a necessary ingredient of effective decarbonisation policies. In the context of the current pandemic, Engström et al. [57] call this kind of reform "excellent climate policies [which] also help deal with the coronavirus crisis by allowing reductions to labour taxes". A plausible explanation for the high score of this measure among Cypriot stakeholders is that this kind of green tax reform (comprising an increase in environmental taxes to be compensated by reductions in labour taxation) has been promoted in Cyprus by some experts since 2015, with a consistent attempt to inform governmental authorities, NGOs and trade unions about its advantages [58]. The resulting top performance in this assessment may be an indication that targeted and well-supported information flows to diverse stakeholders have been effective and may lead to societal acceptance of such a reform in the near future.

To check the robustness of the above findings, we ran a number of sensitivity cases. It turned out that the ranking of measures shown in Table 2 is quite robust to variations of the weight of individual criteria. Similarly, the preferences do not substantially change according to whether the stakeholders are government officers or work in the private sector or NGOs. Conversely, it seems that economists in our sample (four out of ten decision makers) had considerably different input than engineers and natural scientists who formed the rest of the sample. Economists preferred three types of measures: a regulatory change with no cost (virtual net billing – M5), grants/loans to businesses (M6 and M7) and energy renovations of buildings (measures M1 and M3). It seems that their earlier policy experience has led them to conclude that building renovations are the most realistic technological interventions, whereas they are sceptical towards carbon taxation, probably in view of its political cost. It is thus impressive that non-economists strongly consider the carbon tax as their preferred measure, so that it ranks first in the overall ranking despite the scepticism of economists.

4. Conclusions

A set of policy recommendations can be extracted from the findings of the analysis. Firstly, it is evident that a variety of measures is needed to achieve economic growth without compromising environmental sustainability. Even though the carbon tax reform has received the top score, it does not mean that implementation of this measure on its own can have the desired impact across the entire set of criteria. At the same time, this measure's high ranking, which has been in discussion with local stakeholders already for several years, highlights the importance of information campaigns to increase awareness of the potential benefits of a certain action. This helps to build consensus that permits gradual implementation and social acceptance of reputedly unfavourable policies. Additionally, the weights and scores given by the stakeholders indicate that great significance is given on the perceived plausibility of actual implementation of certain measures. As such, measures that can lead to considerable reductions in carbon dioxide emissions, such as the Nicosia tram or the Sustainable Urban Mobility Plans, perform relatively poorly. The success of these measures will be determined to a great extent to the political will of the responsible authorities, as they will be quite costly, their implementation will require several years, while their benefits can be expected primarily in the long-term.

Our analysis illustrates the importance of combining simple methods with more sophisticated models for an assessment of recovery measures that can provide meaningful support to policymakers. Moreover, our findings clearly demonstrate trade-offs between the short-term (2022), the long-term (2030) and the climate neutrality (2050) targets, as well as the superiority of many green measures in comparison to business-*as*-usual demand stimulus. Some immediate measures with attractive short-term impact have short-lived benefits and turn out to be inferior in both economic and environmental terms by 2030. This is in line with the finding of Barbier [12] that a different policy mix is required for short-term interventions as compared to a medium to long-term strategy for a recovery leading to a green transition. Institutional or regulatory changes, such as the gradual implementation of carbon pricing or the reform of electricity rules to enable decentralised power generation, may have long-term impacts with low cost. Blunt economy-wide demand stimulus measures are not only environmentally unsustainable but also economically mediocre – they perform worse in promoting economic growth and employment than most of the examined measures. This provides solid quantitative evidence (which can be found in very few studies in the literature) against a 'return-to-normal' stimulus. The final ranking of appropriate measures, benefiting from input by diverse societal stakeholders, contributes to the 'democratisation' of the policy formulation process [29] and enables ownership of the measures by national decision makers. Linking the sustainability criteria with the UN SDGs facilitates the alignment of national recovery programmes with the international policy agenda.

This analysis provides useful insights into the opportunities to green the post-pandemic recovery. However, it needs to be complemented by a broader look at the full package of recovery measures, including those that are not directly related to energy and climate change. For instance, public investments will be directed to health and social care infrastructures as well as information and communication technology, and green and climate considerations will need to be included in the design of these investments. Modernisation of hospitals and schools increases welfare of the population and, if it includes for instance energy efficiency renovations and proper management of hazardous waste, can as well improve resilience and reduce carbon emissions.

It is always possible to do more analyses and mobilise more sophisticated models to cover more dimensions of the problem and refine the policy prioritisation process. In particular, future research could analyse the economy-wide rebound effects of energy efficiency improvements in terms of CO_2 emissions through the application of an energy IO model. At the same time, a crisis by definition is a situation where timeliness is critical, and it would not make sense to take years to provide the ideal recovery package. Our two-step approach – combining modelling when tools and data are available, and experts' and stakeholders' opinion to complement quantified results and prioritise action – is one solution to find a compromise between timeliness and confidence, and to ensure that decision makers do not have to apply blindly the result of a model. As demonstrated recently [59], free and open-source energy, environmental and economic models can be rapidly developed and adapted to a new national context [9]. The speed and transparency of such modelling systems allows for transparent auditing and model improvement, which helps tailor them to national needs. Complementing this open modelling environment with qualitative data can help overcome issues of missing data and fragmented models; hence this framework can be applied in multiple contexts for sustainable economic recovery and climate compatible growth, including where data and models are less easily available than in the EU.

Future applications of the presented framework can be tested in countries or regions beyond the EU. However, this may require potential adjustments to make the methodology more applicable to the local context. Additionally, the approach does not need to be limited to post-pandemic recovery, but can be adopted to address economic recovery in a broader context. For instance, in regions hit by recent conflicts, such as Ukraine, the list of criteria can be expanded to include security aspects or take into account the need for reconstruction of crucial infrastructure.

Author contributions statement

TZ: Funding acquisition, Conceptualization, Methodology, Writing - Original Draft, Supervision, Project administration; **EG**: Software, Validation, Formal analysis, Investigation, Writing - Original Draft; **CT**: Software, Validation, Formal analysis, Investigation, Writing - Review & Editing; **MK**: Methodology, Software, Validation, Formal analysis, Investigation, Data curation, Visualization, Writing - Original Draft; **NF**: Conceptualization, Validation, Formal analysis, Writing - Review & Editing; **MH**: Conceptualization, Writing - Review & Editing; **WB**: Writing - Review & Editing; **SH**: Conceptualization, Resources, Writing - Review & Editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data are available in an open website, and we have declared this in the manuscript.

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Appendices.

Appendix A. List of Green Recovery Measures

Table A. 1
Description of the proposed green recovery measures

#	Title	Description	Comments
M1	Immediate launch of grant scheme for energy renovations of buildings from unused budget of 2020–21	For energy renovations in existing residential, commercial and public buildings which can become near-zero energy buildings or can yield energy savings of at least 40%.	€30 million (national and EU funds) can be used immediately because €15 million are still available from EU Structural Funds of the period 2014–2020. Proposal: Spend this amount by December 31, 2021.
M2	New grant scheme for energy renovations of existing buildings, 2021-27	For energy renovations in existing residential, commercial and public buildings which can become near-zero energy buildings **or** can yield energy savings of at least 40%.	€70 million (national and EU funds) have been requested for the period 2021–27 (50% of the total cost). Proposal: Spend this amount by December 31, 2022, with the prospect to increase it later. The previous similar programme was successful. As the proposed scheme is much larger, simpler procedures are needed to ensure fast implementation.
M3	Grants for energy renovations of buildings under construction for upgrade to Near-Zero Energy Buildings (NZEB)	Increased state guarantees and/or grants and/or tax credits to residential & commercial buildings under construction (which have not been connected to the electricity grid yet) and to buildings that have obtained a building permit after January 1, 2018, so that they can immediately be upgraded to NZEB.	Grants of €70 million could be allocated between residential & commercial buildings (maximum: 7000 buildings). If increased state guarantees are adopted there is no immediate cost. This measure will yield immediate improvement in energy efficiency of new buildings beyond mandatory requirements. *New proposal, currently not included in National Energy and Climate Plan.*
M4	Installation of smart electricity meters	Installation of 400.000 smart meters by EAC	Important measure to enable high penetration of renewable electricity, in implementation of Directive 2019/944/EU. The installation is scheduled to be completed by the end of 2027. Proposal: complete this installation by December 31, 2023 in collaboration with private installers. Implementation cost estimated at €55 million.
M5	Virtual net billing for encouragement of photovoltaic installations by enterprises	PV installation by enterprises with virtual net billing (or virtual net-metering for multi-apartment buildings) method and/or from individuals through renting the roofs of their houses	Regulatory change is required with the consent of CERA. It is a low-cost measure with large benefits for the penetration of renewable electricity. Administrative cost estimated at €500,000. *New proposal, currently not included in National Energy and Climate Plan.*
M6	Subsidy to loans of businesses certified with an environmental management system	As an economic stimulus measure, Interest rates of business loans will be subsidised by the government. It is proposed that the interest rate to be subsidised is 0.5% higher for those firms that have adopted or will adopt the EU Eco-Management and Labelling Scheme EMAS by December 31, 2021. The certification process can be subsidised with a small grant of the order of €2000 per firm.	This measure will cost approximately €2 million and can yield fast improvement in energy efficiency and/or environmental performance of businesses. *New proposal, currently not included in National Energy and Climate Plan.*
M7			

(*continued on next page*)

Table A. 1 (*continued*)

#	Title	Description	Comments
	Business4Climate scheme – grants to enterprises with a verified low-carbon action plan up to 2030	Continuation of the pilot scheme 'Business4Climate', which provides grants to firms of all sectors which provide a credible Action Plan to reduce their carbon footprint by 2030	Grants of €20 million can be allocated. This measure will yield fast improvement in energy efficiency and/or environmental performance of businesses.
M8	Implementation of existing Sustainable Urban Mobility Plans	Immediate implementation of the SUMP of Limassol which has been completed. Implementation of SUMPs of Nicosia and Larnaca as soon as the respective plans have been finished. (Does not include cost of additional buses)	SUMPs are extremely important for the elimination of fossil fuel use in transport. Implementation cost of Limassol SUMP: €170 million up to 2032. Proposal: Provide €100 million for fast application of SUMP of Limassol + start of implementation of SUMPs of the cities of Larnaca & Nicosia by December 31, 2022.
M9	Construction of tram in the capital city of Nicosia	Construction of tram lines in Nicosia	This is s a longer-term measure, with an investment cost of €225 million, but with potentially significant impact, hence it is added separately from the broader SUMP measure. Also, even though focused on international rail travel, the EU's draft Green Recovery Plan puts an emphasis on shifting passenger transport to rail services.
M10	Scrappage scheme for old cars to be replaced with battery electric vehicles	Grant to scrap an old car and replace it with a fully electric car; scheme to last for two years, 2021 and 2022	5000 Euros grant for each old car that is scrapped and replaced with a fully electric one. The total budget of the measures is €10 million.
M11	Replacement of streetlights in municipalities and villages with energy efficient lighting	Replacement of street lighting in municipalities and communities. In 2018 a financial instrument was established for Municipalities and Communities, through which they can apply for a loan to the Ministry of the Interior for the replacement of street lighting. At the moment, eleven municipalities have been approved. It is expected that more Municipalities will participate in the financial instrument in 2020 and 2021.	Very cost-effective measure. Total cost estimated at €45 million. Target: Change 300.000 lamps by December 31, 2021 - currently about half of these lamps are planned to change by that time.
M12	Tree planting along urban and intercity roads	Extensive tree planting of up to 650,000 trees along the urban road network and up to 350,000 trees along the interurban road network.	1. Shading, lowering temperatures and better walking and cycling conditions may cause an additional shift from car to sustainable modes of transport. 2. CO_2 absorption. 3. Aesthetic upgrade and urban landscaping of all cities and rural routes. Total cost of implementation is estimated at €85 million.
M13	Fiscally neutral carbon taxation for economic sectors out of the EU Emissions Trading System	Tax up to €120/tonne of carbon dioxide on non-ETS sectors, i.e. on all fossil fuels except those used for power generation and by cement plant and brick factories.	Gradual introduction within 5 years. Expected public revenues in full implementation: €100–150 million/year. Tax revenues could be rebated to all households to increase political acceptance. Administrative cost estimated at €500,000.

Appendix B. Assessment Criteria

Table B.1

Criteria used for the evaluation of green economic recovery measures and their relation to UN Sustainable Development Goals (SDGs).
i) Performance criteria for the short term (for the next 2 years):ii) Performance criteria for the longer term (mostly for 2030):

	Short name	Explanation	Related SDGs
Environmental impact	Energy	Energy savings (ktoe) per million Euros invested	7
	CO2	CO_2 emission savings (tn) per million Euros invested	13
	Other Environmental Impact	Other short-term environmental impact (on air quality, nature, water resources, land productivity, biodiversity etc)	3, 6, 11
Economic/social impact	Economic multiplier	Economic output generation (million €) per million Euros invested	8
	Jobs	Net employment generation (persons) per million Euros invested	8
	Demand in affected sectors	Does the initiative generate demand in the most affected sectors? Or does this initiative target new or different sectors? If in a different sector, can the workforce easily shift to this new sector? Does the initiative include measures to facilitate the transition of workers and the required investments?	4, 8
	Time to Implement	How long will it take to fully implement this initiative and to create jobs and activity (including project design, consultation processes, budget mobilization, procurement, etc.)?	8
	Infrastructure & Productivity	Does the measure improve existing infrastructure? Does this affect productivity in the short term?	9
	Technical feasibility	Is the intervention technically feasible with the country's capacity and know-how?	
	Affordability	Is there a risk that vulnerable households or firms will incur high costs due to the measure?	1, 10
	Social acceptance	Is the measure socially acceptable? Can it contribute to social objectives like reducing poverty and precarity?	1, 10

	Short name	Explanation	Related SDGs
Environmental impact	Energy	Energy savings (ktoe) per million Euros invested	7
	CO2	CO_2 emission savings (tn) per million Euros invested	13
	Low-carbon technologies/ strategies	Does the intervention provide the technical means to better integrate or employ low-carbon technologies or strategies (for instance, through improvements to transmission and distribution infrastructure, public transit infrastructure, sidewalks or bike lanes, or by promoting denser urban development) that may yield benefits **beyond the year 2030**? Does it contribute to a deep decarbonisation objective **by 2050**?	13, 15
	Other Environmental Impact	Other short-term environmental impact (on air quality, nature, water resources, land productivity, biodiversity etc)	3, 6, 11, 15

(*continued on next page*)

Table B.1 (*continued*)

	Short name	Explanation	Related SDGs
Economic/social impact	Economic multiplier	Economic output generation (million €) per million Euros invested	8
	Jobs	Net employment generation (persons) per million Euros invested	8
	Energy security	Does the intervention increase local/national energy security?	7
	Infrastructure & Productivity	Will the intervention improve local economic productivity through access to better, more reliable infrastructure services?	9
	R&D and innovation	Can the intervention spur R&D or innovation in the specific technologies?	9
	Market Failures	Will the intervention address market failures, such as market distorting subsidies, pricing that fails to account for externalities, etc.?	8
	Economic/Climate Resilience	Does the intervention improve socio-economic resilience, that is, the ability of the population to cope with and recover from shocks? Does it improve their adaptive capacity, that is their ability to reduce negative impacts (such as adapting buildings to improve resilience to extreme temperature)?	1, 8, 10, 11
	Decarbonisation/Effect on NDC	Does the measure contribute substantially to decarbonisation of the economy by 2030? Does it significantly affect the country's NDC to be submitted to UNFCCC?	12, 13

Appendix C. Input-Output model

Table C. 1
Annual spending associated with investments and households' consumption under the Car Scrappage Measure relative to the Reference Scenario by sector of economic activity for the period 2020–2030 (in million Euros)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Agriculture	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forestry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food Manufacturing	0.00	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood and Paper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical and Plastic Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metal Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery and Equipment	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Energy	0.00	0.09	0.12	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Construction	0.00	0.35	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trade	0.00	0.42	0.33	−0.19	−0.19	−0.19	−0.19	−0.20	−0.20	−0.20	−0.20
Accommodation and Food Services	0.00	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Transportation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Banking-Financing	0.00	0.12	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Real Estate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Public Administration	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Education	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Health	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Other Services	0.00	0.01	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

Table C.2
Annual spending associated with investments and households' consumption under the ISUI1 Measure relative to the Reference Scenario by sector of economic activity for the period 2020–2030 (in million Euros)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forestry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food Manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood and Paper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical and Plastic Products	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metal Products	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery and Equipment	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.00	−0.07	−0.34	−0.69	−1.05	−1.05	−1.07	−1.08	−1.09	−1.11	−1.12
Construction	0.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trade	0.00	0.92	0.12	0.25	0.38	0.38	0.39	0.39	0.40	0.40	0.41
Accommodation and Food Services	0.00	0.01	0.04	0.08	0.12	0.12	0.12	0.13	0.13	0.13	0.13
Transportation	0.00	0.01	0.05	0.11	0.16	0.16	0.17	0.17	0.17	0.17	0.17
Banking-Financing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Real Estate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Public Administration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Education	0.00	0.00	0.02	0.04	0.06	0.06	0.06	0.06	0.06	0.07	0.07
Health	0.00	0.00	0.02	0.05	0.07	0.07	0.07	0.07	0.07	0.07	0.08
Other Services	0.00	0.01	0.07	0.14	0.22	0.22	0.22	0.22	0.23	0.23	0.23

Table C. 3
Annual spending associated with investments and households' consumption under the ISUI2 Measure relative to the Reference Scenario by sector of economic activity for the period 2020–2030 (in million Euros)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forestry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food Manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood and Paper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical and Plastic Products	0.00	3.50	3.50	1.40	1.40	1.40	1.40	1.40	0.00	0.00	0.00
Metal Products	0.00	1.75	1.75	0.70	0.70	0.70	0.70	0.70	0.00	0.00	0.00
Machinery and Equipment	0.00	1.75	1.75	0.70	0.70	0.70	0.70	0.70	0.00	0.00	0.00
Energy	0.00	−0.10	−0.24	−0.50	−1.22	−1.76	−2.14	−2.89	−2.92	−2.96	−2.98
Construction	0.00	17.50	17.50	7.00	7.00	7.00	7.00	7.00	0.00	0.00	0.00
Trade	0.00	1.09	1.14	0.60	0.86	1.06	1.20	1.47	1.06	1.07	1.08
Accommodation and Food Services	0.00	0.01	0.03	0.06	0.14	0.20	0.25	0.34	0.34	0.34	0.35
Transportation	0.00	0.02	0.04	0.08	0.19	0.27	0.33	0.45	0.46	0.46	0.47
Banking-Financing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Real Estate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Public Administration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Education	0.00	0.01	0.01	0.03	0.07	0.10	0.13	0.17	0.17	0.17	0.17
Health	0.00	0.01	0.02	0.03	0.08	0.12	0.14	0.19	0.20	0.20	0.20
Other Services	0.00	0.02	0.05	0.10	0.25	0.36	0.44	0.60	0.60	0.61	0.62

Table C. 4
Annual spending associated with investments and households' consumption under the Nicosia Tram Measure relative to the Reference Scenario by sector of economic activity for the period 2020–2030 (in million Euros)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forestry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food Manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood and Paper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical and Plastic Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metal Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery and Equipment	0.00	0.00	0.00	0.08	0.16	0.16	0.16	0.16	0.41	0.41	0.41
Energy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.77	6.80	6.81
Construction	0.00	0.00	0.00	6.25	12.50	12.50	12.50	12.50	1.18	1.18	1.18
Trade	0.00	0.00	0.00	1.31	2.63	2.63	2.63	2.63	−19.7	−19.7	−19.8
Accommodation and Food Services	0.00	0.00	0.00	0.13	0.25	0.25	0.25	0.25	2.37	2.38	2.38
Transportation	0.00	0.00	0.00	2.58	5.15	5.15	5.15	5.15	3.18	3.20	3.21
Banking-Financing	0.00	0.00	0.00	0.50	1.00	1.00	1.00	1.00	0.94	0.94	0.94
Real Estate	0.00	0.00	0.00	0.75	1.50	1.50	1.50	1.50	0.24	0.24	0.24
Public Administration	0.00	0.00	0.00	0.13	0.25	0.25	0.25	0.25	0.00	0.00	0.00
Education	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20	1.20	1.20
Health	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37	1.38	1.38
Other Services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.23	4.25	4.26

Table C. 5
Annual spending associated with investments and households' consumption under the preNZEB Measure relative to the Reference Scenario by sector of economic activity for the period 2020–2030 (in million Euros)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forestry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food Manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood and Paper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical and Plastic Products	0.00	5.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metal Products	0.00	2.50	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery and Equipment	0.00	2.50	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.00	−0.17	−0.17	−0.17	−0.17	−0.18	−0.18	−0.18	−0.18	−0.18	−0.19
Construction	0.00	25.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trade	0.00	1.56	0.66	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07
Accommodation and Food Services	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Transportation	0.00	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03

(*continued on next page*)

Table C. 5 (*continued*)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Banking-Financing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Real Estate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Public Administration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Education	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Health	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Other Services	0.00	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

Table C. 6
Annual spending associated with investments and households' consumption under the Public Lighting Measure relative to the Reference Scenario by sector of economic activity for the period 2020–2030 (in million Euros)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forestry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food Manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood and Paper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical and Plastic Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metal Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery and Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.00	5.67	3.02	0.33	0.33	0.34	0.34	0.34	0.35	0.35	0.35
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trade	0.00	0.13	0.27	0.36	0.36	0.37	0.37	0.38	0.38	0.38	0.39
Accommodation and Food Services	0.00	0.04	0.09	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Transportation	0.00	0.06	0.12	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.17
Banking-Financing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Real Estate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Public Administration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Education	0.00	0.02	0.04	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Health	0.00	0.02	0.05	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Other Services	0.00	5.16	1.96	−1.09	−1.10	−1.10	−1.12	−1.13	−1.14	−1.15	−1.16

Table C. 7
Annual spending associated with investments and households' consumption under the Smart Meters Measure relative to the Reference Scenario by sector of economic activity for the period 2020–2030 (in million Euros)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forestry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food Manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood and Paper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical and Plastic Products	0.00	1.50	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metal Products	0.00	0.75	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery and Equipment	0.00	0.75	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.00	−0.03	−0.06	−0.09	−0.20	−0.31	−0.42	−0.54	−0.55	−0.55	−0.56
Construction	0.00	7.50	10.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trade	0.00	0.46	0.62	0.63	0.07	0.11	0.15	0.20	0.20	0.20	0.20
Accommodation and Food Services	0.00	0.00	0.01	0.01	0.02	0.04	0.05	0.06	0.06	0.06	0.06
Transportation	0.00	0.00	0.01	0.01	0.03	0.05	0.07	0.08	0.09	0.09	0.09
Banking-Financing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Real Estate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Public Administration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Education	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.03
Health	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.04	0.04	0.04	0.04
Other Services	0.00	0.01	0.01	0.02	0.04	0.06	0.09	0.11	0.11	0.11	0.12

Table C. 8
Annual spending associated with investments and households' consumption under the SUMP Measure relative to the Reference Scenario by sector of economic activity for the period 2020–2030 (in million Euros)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forestry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food Manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood and Paper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical and Plastic Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metal Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery and Equipment	0.00	0.12	0.12	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.00	2.13	4.27	6.45	8.61	10.73	12.92	15.06	9.06	11.26	13.39
Construction	0.00	10.00	10.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trade	−0.01	−4.13	−10.4	−17.8	−25.2	−31.4	−37.8	−44.0	−26.5	−32.9	−39.1
Accommodation and Food Services	0.00	0.95	1.69	2.36	3.01	3.75	4.52	5.27	3.17	3.94	4.68
Transportation	0.00	5.12	6.13	5.09	4.05	5.05	6.08	7.09	4.26	5.30	6.30
Banking-Financing	0.00	0.80	0.80	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Real Estate	0.00	1.20	1.20	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Public Administration	0.00	0.20	0.20	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Education	0.00	0.38	0.75	1.14	1.52	1.90	2.28	2.66	1.60	1.99	2.37
Health	0.00	0.43	0.86	1.31	1.74	2.17	2.62	3.05	1.84	2.28	2.71
Other Services	0.00	1.33	2.67	4.03	5.38	6.70	8.07	9.41	5.66	7.04	8.37

Table C. 9
Annual spending associated with investments and households' consumption under the Virtual Net Billing Measure relative to the Reference Scenario by sector of economic activity for the period 2020–2030 (in million Euros)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forestry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food Manufacturing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood and Paper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemical and Plastic Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metal Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery and Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Energy	0.00	0.04	0.09	0.13	0.17	0.22	0.26	0.30	0.35	0.39	0.43
Construction	0.00	2.93	2.89	2.84	2.80	2.75	2.71	2.66	2.62	2.57	2.53
Trade	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accommodation and Food Services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation	0.00	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06
Banking-Financing	0.00	0.08	0.08	0.09	0.09	0.10	0.10	0.11	0.12	0.12	0.13
Real Estate	0.00	0.24	0.27	0.29	0.31	0.33	0.35	0.37	0.39	0.42	0.44
Public Administration	0.00	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06
Education	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Health	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table C.10
Annual spending associated with households' consumption under the Counterfactual Scenario (Uniform Economy-Wide Demand Stimulus) relative to the Reference Scenario by sector of economic activity for the period 2020–2030 (in million Euros)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Agriculture	0.22	3.37	2.29	1.42	1.19	1.18	1.18	1.18	0.20	0.19	0.00
Forestry	0.01	0.18	0.12	0.08	0.06	0.06	0.06	0.06	0.01	0.01	0.00
Mining	0.01	0.18	0.12	0.08	0.06	0.06	0.06	0.06	0.01	0.01	0.00
Food Manufacturing	0.72	10.88	7.41	4.59	3.84	3.83	3.82	3.81	0.64	0.62	0.00
Textile	0.19	2.92	1.99	1.23	1.03	1.03	1.03	1.02	0.17	0.17	0.00
Wood and Paper	0.04	0.62	0.42	0.26	0.22	0.22	0.22	0.22	0.04	0.04	0.00
Chemical and Plastic Products	0.63	9.48	6.45	4.00	3.35	3.34	3.33	3.32	0.55	0.54	0.00
Metal Products	0.10	1.50	1.02	0.63	0.53	0.53	0.52	0.52	0.09	0.09	0.00
Machinery and Equipment	1.65	24.71	16.83	10.43	8.73	8.70	8.68	8.65	1.44	1.42	0.00
Energy	0.10	1.50	1.02	0.63	0.53	0.53	0.53	0.53	0.09	0.09	0.00
Construction	0.60	9.04	6.16	3.82	3.19	3.18	3.18	3.17	0.53	0.52	0.00
Trade	0.94	14.18	9.66	5.99	5.01	4.99	4.98	4.96	0.83	0.81	0.00
Accommodation and Food Services	1.08	16.21	11.04	6.84	5.72	5.71	5.69	5.67	0.95	0.93	0.00
Transportation	1.51	22.66	15.43	9.57	8.00	7.98	7.96	7.93	1.32	1.30	0.00

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Table C.10 (*continued*)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Banking-Financing	2.22	33.32	22.69	14.07	11.77	11.73	11.70	11.66	1.95	1.91	0.00
Real Estate	0.79	11.90	8.10	5.02	4.20	4.19	4.18	4.17	0.69	0.68	0.00
Public Administration	0.76	11.42	7.78	4.82	4.03	4.02	4.01	4.00	0.67	0.66	0.00
Education	0.56	8.34	5.68	3.52	2.94	2.94	2.93	2.92	0.49	0.48	0.00
Health	0.51	7.59	5.17	3.21	2.68	2.67	2.66	2.66	0.44	0.44	0.00
Other Services	2.01	30.23	20.58	12.76	10.67	10.64	10.61	10.58	1.77	1.73	0.00

Table C11. NACE (Statistical classification of economic activities in the European Union) codes of the sectors of economic activity that make up the 20 sectors for the

Sector	Description NACE
Agriculture	A01, A03
Forestry	A02
Mining	B
Food Manufacturing	C10, C11, C12
Textile	C13, C15
Wood and Paper	C16, C17, C18
Chemical and Plastic Products	C19–C23
Metal Products	C24, C25
Machinery and Equipment	C26–C33
Energy	D
Construction	F
Trade	G45–G47
Accommodation and Food Services	I
Transportation	H49–H53
Banking-Financing	K64–K66
Real Estate	L68
Public Administration	O
Education	P
Health	Q
Other Services	E, J58–63, M69–75, N, R, S, T, U

Appendix D. Description of the AHP and PROMETHEE Methods

D.1. AHP Method

AHP is a pairwise comparison method which uses a ratio scale that does not require any units. DMs express their preferences for one alternative over another one. The number of comparisons is $\frac{n^2-n}{2}$, expressed in an $n \times n$ pairwise comparison matrix. Typically, DMs express their preferences using a 1–9 scale, which is assumed to offer the appropriate flexibility.

One important aspect of this method is that the pairwise comparison matrix needs to be consistent, which becomes more difficult for matrices with large dimensions. This can be checked via the consistency ratio as shown in eqs. (1) and (2).

$$CR(X) = \frac{CI(X)}{RI_n} \tag{1}$$

$$CI(X) = \frac{\lambda_{max} - n}{n-1} \tag{2}$$

Where $CI(X)$ the consistency index, RI_n a real number that estimates the average CI from a large dataset of randomly generated matrices of size n and estimations can be found in literature, and λ_{max} the maximum eigenvector [60]. It is suggested that matrices with $CR > 0.1$ are inconsistent.

The priorities can be calculated typically by three methods, namely: (i) the eigenvector method, (ii) the normalised column sum method, and (iii) the geometric mean method. In this paper the geometric mean method has been applied, where the priority vector is calculated as the geometric mean of the elements on a row, over the respective normalisation term in order for the sum of the weights to be equal to 1, as shown in eq. (3):

$$w_i = \frac{\left(\prod_{j=1}^{n} x_{ij}\right)^{1/n}}{\sum_{i=1}^{n}\left(\prod_{j=1}^{n} x_{ij}\right)^{1/n}} \tag{3}$$

In the framework of this study the 23 criteria shown in Table 2 have been divided into two broad categories of short- and long-term impacts and further subdivided into two subcategories, namely: (i) environmental criteria, and (ii) economic/social criteria, as shown in Figures D1 to D.3.

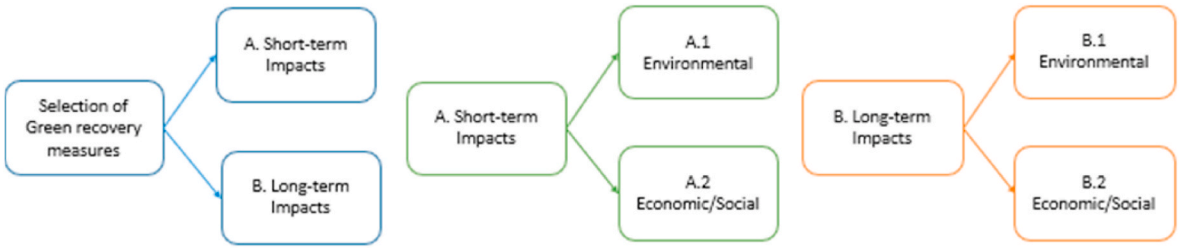

Fig. D.1. AHP framework for prioritisation of green recovery measures based on short- and long-term impacts

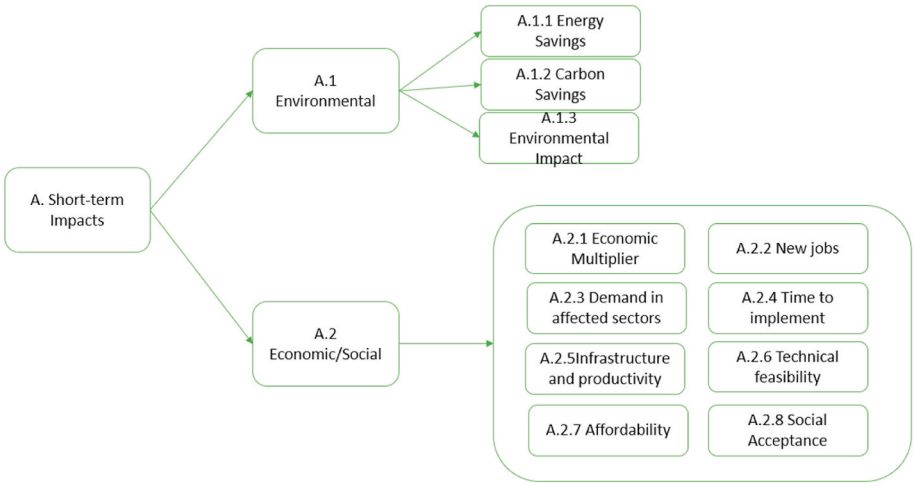

Fig. D.2. AHP framework for prioritisation of green recovery measures based on short environmental and economic/social impacts

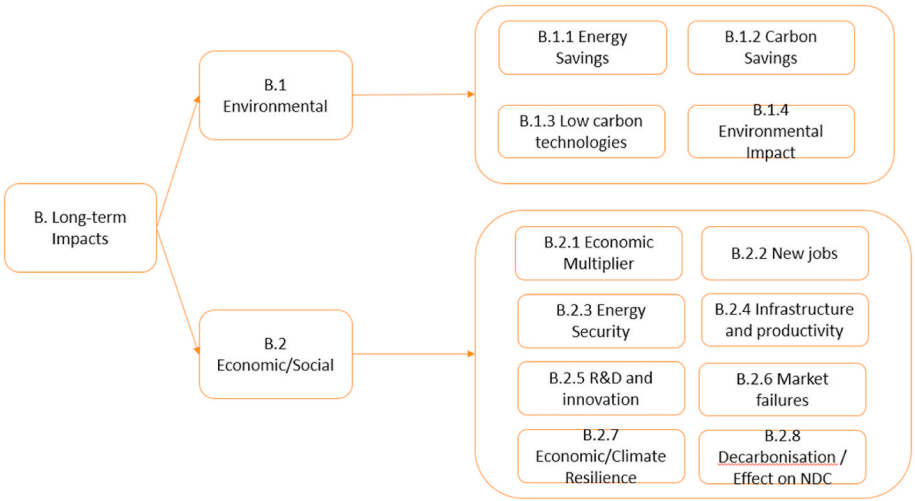

Fig. D.3. AHP framework for prioritisation of green recovery measures based on long environmental and economic/social impacts

D.2. PROMETHEE Method

For the evaluation and ranking of the alternatives the PROMETHEE method has been applied. The independent experts were asked to evaluate each alternative (or action as it is called in PROMETHEE terminology) for each criterion. The remaining criteria are qualitative, and the DMs were asked to express their evaluation in a typical 1–5 scale ranging from very low to very high. In PROMETHEE each action is compared to $(m-1)$ other actions in order to calculate the positive and negative outranking flow of each action as a number between 0 and 1. These values express how much this action is preferred over all the other ones as shown in eqs. (4) and (5):

$$\varphi^{+} = \frac{1}{m-1}\sum_{x \in A}\pi(a,x) \tag{4}$$

$$\varphi^{-} = \frac{1}{m-1}\sum_{x \in A}\pi(a,x) \tag{5}$$

While the PROMETHEE I method offers a partial ranking between the alternatives, the PROMETHEE II method was used, which can offer a complete ranking amongst all the actions. In PROMETHEE II the net flow needs to be calculated in order to rank the actions, according to eqs. (6) and (7):

$$\varphi(a) = \varphi^{+}(a) - \varphi^{-}(a) = \frac{1}{m-1}\sum_{j=1}^{n}\sum_{x\in A}\left[P_j(a,x) - P_j(x,a)\right]w_j \tag{6}$$

and

$$\varphi(a) = \sum_{j=1}^{n}\varphi_j(a)w_j \tag{7}$$

For the pairwise comparison a Type 5 V-shape preference function has been used, which considers a preference (p) and indifference (q) threshold as shown in Figure D.4.

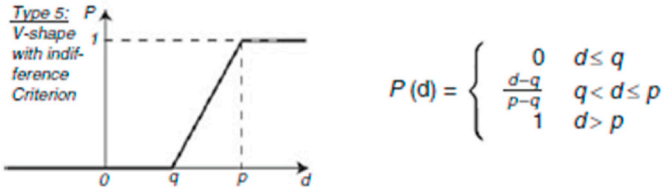

Fig. D.4. The type 5 preference function [61]

As there are several DMs, the PROMETHEE GDSS is implemented. At the final stage of this method a global evaluation takes place; after the individual evaluation from each expert a global matrix is constructed with the rows being the alternatives and the columns the flow values calculated by the DMs. We assumed that the weights of the DMs are equal and that the preference function is of the same type. It is noted that the DMs have agreed to the preference and indifference thresholds. Then the PROMETHEE method is applied which gives the final ranking.

Appendix E. AHP and PROMETHEE Input Tables

Table E1. Pairwise comparison between short- and long-term impacts using the AHP scale (please fill only the blank cells)

	Short-term impacts	Long-term impacts
Short-term impacts	1	
Long-term impacts		1

Table E2. Pairwise comparison between short-term "Energy/Environmental" and "Economic/Social" criteria using the AHP scale (please fill only the blank cells)

	Energy/Environmental	Economic/Social
Energy/Environmental	1	
Economic/Social		1

Table E3. Pairwise comparison between long-term "Energy/Environmental" and "Economic/Social" criteria using the AHP scale (please fill only the blank cells)

	Energy/Environmental	Economic/Social
Energy/Environmental	1	
Economic/Social		1

Table E4. Pairwise comparison between short-term "Energy/Environmental" criteria using the AHP scale (please fill only the blank cells)

	Energy savings	CO2 savings	Environmental Impact
Energy savings	1		
CO2 savings		1	
Environmental Impact			1

Table E5. Pairwise comparison between short-term "Economic/Social" criteria using the AHP scale (please fill only the blank cells)

	Economic multiplier	Net new jobs	Demand in affected sectors	Time to Implement	Infrastructure & Productivity	Technical feasibility	Affordability	Social acceptance
Economic multiplier	1							
Net new jobs		1						
Demand in affected sectors			1					
Time to Implement				1				
Infrastructure & Productivity					1			
Technical feasibility						1		
Affordability							1	
Social acceptance								1

Table E6. Pairwise comparison between long-term "Energy/Environmental" criteria using the AHP scale (please fill only the blank cells)

	Energy savings	CO2 savings	Environmental Impact	Low-carbon technologies/strategies
Energy savings	1			
CO2 savings		1		
Environmental Impact			1	
Low-carbon technologies/strategies				1

Table E7. Pairwise comparison between long-term "Economic/Social" criteria using the AHP scale (please fill only the blank cells)

	Economic multiplier	Net new jobs	Energy security	Infrastructure & Productivity	R&D and innovation	Market Failures	Economic/Climate Resilience	Decarbonisation/Effect on NDC
Economic multiplier	1							
Net new jobs		1						
Energy security			1					
Infrastructure & Productivity				1				
R&D and innovation					1			
Market Failures						1		
Economic/Climate Resilience							1	
Decarbonisation/Effect on NDC								1

Table E8. Evaluation of measures regarding short-term impacts using the qualitative scale (1–5)

		Short-term Impacts						
		Energy/ Environmental	Economic/Social					
		Environmental Impact	Demand in affected sectors	Time to Implement	Infrastructure & Productivity	Technical feasibility	Affordability	Social acceptance
M1	Immediate launch of grant scheme for energy renovations of buildings from unused budget of 2020–21							
M2	New grant scheme for energy renovations of existing buildings, 2021–27							
M3	Grants for energy renovations of buildings under construction for upgrade to Near-Zero Energy Buildings (NZEB)							
M4	Installation of smart electricity meters							
M5	Virtual net billing for encouragement of photovoltaic installations by enterprises							
M6	Subsidy to loans of businesses certified with an environmental management system							
M7	Business4Climate scheme – grants to enterprises with a verified low-carbon actin plan up to 2030							
M8	Implementation of existing Sustainable Urban Mobility Plans							
M9								

(continued on next page)

(*continued*)

		Short-term Impacts						
		Energy/ Environmental	Economic/Social					
		Environmental Impact	Demand in affected sectors	Time to Implement	Infrastructure & Productivity	Technical feasibility	Affordability	Social acceptance
	Construction of tram in the capital city of Nicosia							
M10	Scrappage scheme for old cars to be replaced with battery electric vehicles							
M11	Replacement of streetlights in municipalities and villages with energy efficient lighting							
M12	Tree planting along urban and intercity roads							
M13	Fiscally neutral carbon taxation for economic sectors out of the EU Emissions Trading System							

Table E9. Evaluation of measures regarding long-term impacts using the qualitative scale (1–5)

		Long-term Impacts							
		Energy/Environmental		Economic/Social					
		Low-carbon technologies / strategies	Environmental Impact	Energy security	Infrastructure & Productivity	R&D and innovation	Market Failures	Economic/ Climate Resilience	Decarbonisation/ Effect on NDC
M1	Immediate launch of grant scheme for energy renovations of buildings from unused budget of 2020–21								
M2	New grant scheme for energy renovations of existing buildings, 2021–27								
M3	Grants for energy renovations of buildings under construction for upgrade to Near-Zero Energy Buildings (NZEB)								
M4	Installation of smart electricity meters								
M5	Virtual net billing for encouragement of photovoltaic installations by enterprises								
M6	Subsidy to loans of businesses certified with an environmental management system								
M7	Business4Climate scheme – grants to enterprises with a verified low-carbon actin plan up to 2030								
M8	Implementation of existing Sustainable Urban Mobility Plans								
M9	Construction of tram in the capital city of Nicosia								
M10	Scrappage scheme for old cars to be replaced with battery electric vehicles								
M11	Replacement of streetlights in municipalities and villages with energy efficient lighting								
M12	Tree planting along urban and intercity roads								
M13	Fiscally neutral carbon taxation for economic sectors out of the EU Emissions Trading System								

Appendix F. Examples of Stakeholder Input

Table F.1
Weights provided by each DM for the short-term criteria of this study

	A.1.1	A.1.2	A.1.3	A2.1	A2.2	A2.3	A2.4	A2.5	A2.6	A2.7	A2.8
DM1	0.016	0.016	0.031	0.007	0.006	0.006	0.008	0.005	0.014	0.004	0.012
DM2	0.006	0.019	0.059	0.003	0.017	0.003	0.004	0.004	0.015	0.012	0.025
DM3	0.005	0.014	0.014	0.007	0.017	0.048	0.048	0.011	0.008	0.002	0.025
DM4	0.007	0.007	0.007	0.003	0.007	0.005	0.016	0.011	0.035	0.035	0.035
DM5	0.006	0.041	0.036	0.004	0.021	0.008	0.007	0.008	0.010	0.012	0.013
DM6	0.254	0.254	0.254	0.019	0.005	0.043	0.014	0.005	0.005	0.002	0.002
DM7	0.005	0.005	0.005	0.005	0.006	0.004	0.055	0.003	0.009	0.015	0.012
DM8	0.002	0.009	0.009	0.004	0.004	0.021	0.006	0.021	0.021	0.021	0.004
DM9	0.001	0.006	0.007	0.005	0.011	0.032	0.032	0.008	0.005	0.002	0.017
DM10	0.008	0.042	0.017	0.009	0.013	0.009	0.021	0.010	0.008	0.031	0.031

Table F.2
Weights provided by each DM for the long-term criteria of this study

	B.1.1	B.1.2	B.1.3	B.1.4	B2.1	B2.2	B2.3	B2.4	B2.5	B2.6	B2.7	B2.8
DM1	0.136	0.136	0.229	0.081	0.033	0.033	0.039	0.023	0.021	0.016	0.055	0.073
DM2	0.019	0.039	0.263	0.096	0.014	0.045	0.047	0.017	0.046	0.013	0.132	0.105
DM3	0.022	0.158	0.158	0.063	0.034	0.077	0.058	0.038	0.030	0.018	0.074	0.071
DM4	0.009	0.009	0.009	0.076	0.027	0.012	0.012	0.119	0.174	0.038	0.174	0.174
DM5	0.017	0.135	0.135	0.130	0.012	0.044	0.047	0.015	0.043	0.020	0.102	0.134
DM6	0.019	0.025	0.029	0.052	0.002	0.002	0.002	0.001	0.002	0.003	0.003	0.001
DM7	0.191	0.191	0.191	0.191	0.004	0.004	0.018	0.018	0.010	0.007	0.023	0.026
DM8	0.006	0.023	0.023	0.073	0.016	0.168	0.168	0.168	0.037	0.106	0.016	0.071
DM9	0.027	0.027	0.027	0.027	0.064	0.064	0.064	0.064	0.064	0.064	0.191	0.191
DM10	0.076	0.185	0.116	0.266	0.019	0.023	0.021	0.020	0.015	0.007	0.019	0.032

Table F.3
Application of PROMETHEE II: Evaluation scores for short-term criteria by DM1

	Environmental			Economic/Social							
	A.1.1	A.1.2	A.1.3	A2.1	A2.2	A2.3	A2.4	A2.5	A2.6	A2.7	A2.8
M1	0.025	0.149	4.000	0.000	7.935	4.000	4.000	5.000	4.000	3.000	4.000
M2	0.011	0.065	4.000	24.211	27.645	4.000	2.000	3.000	4.000	3.000	4.000
M3	0.015	0.063	4.000	5.504	9.819	4.000	4.000	5.000	4.000	3.000	4.000
M4	0.014	0.085	3.000	42.417	45.326	3.000	3.000	3.000	3.000	4.000	4.000
M5	1.087	4.412	3.000	42.225	45.326	3.000	3.000	3.000	4.000	4.000	4.000
M6	0.272	1.103	3.000	8.083	14.601	3.000	4.000	3.000	3.000	4.000	3.000
M7	0.027	0.110	2.000	8.083	14.601	3.000	4.000	3.000	3.000	4.000	3.000
M8	0.307	0.581	4.000	29.061	2.065	4.000	2.000	3.000	3.000	5.000	3.000
M9	0.000	0.000	4.000	100.000	100.000	4.000	1.000	4.000	3.000	5.000	3.000
M10	0.022	0.037	3.000	6.967	0.000	2.000	4.000	2.000	5.000	3.000	4.000
M11	0.077	0.451	4.000	2.771	13.007	2.000	3.000	3.000	5.000	4.000	4.000
M12	0.000	0.043	2.000	8.083	14.601	2.000	2.000	3.000	3.000	4.000	5.000
M13	100.000	100.000	3.000	8.083	14.601	3.000	2.000	2.000	3.000	3.000	3.000

Table F.4
Application of PROMETHEE II: Evaluation scores for long-term criteria by DM1

	Environmental				Economic/Social							
	B.1.1	B.1.2	B.1.3	B.1.4	B2.1	B2.2	B2.3	B2.4	B2.5	B2.6	B2.7	B2.8
M1	0.044	0.260	4.000	4.000	30.072	92.328	4.000	3.000	2.000	3.000	3.000	4.000
M2	0.019	0.105	5.000	5.000	9.420	87.621	5.000	4.000	4.000	4.000	4.000	5.000
M3	0.005	0.007	3.000	3.000	30.072	88.781	3.000	2.000	2.000	2.000	2.000	2.000
M4	0.011	0.049	4.000	4.000	30.072	89.555	3.000	4.000	2.000	2.000	2.000	2.000
M5	0.333	1.584	4.000	4.000	100.000	100.000	3.000	4.000	2.000	2.000	2.000	2.000
M6	0.083	0.384	3.000	3.000	26.812	88.072	2.000	3.000	4.000	3.000	3.000	3.000
M7	0.009	0.024	3.000	3.000	26.812	88.072	2.000	3.000	4.000	3.000	3.000	3.000
M8	0.194	0.344	5.000	5.000	21.739	0.000	4.000	5.000	3.000	3.000	5.000	5.000
M9	0.022	0.028	5.000	5.000	0.000	66.925	4.000	5.000	3.000	3.000	5.000	4.000
M10	0.008	0.000	3.000	3.000	21.739	79.884	2.000	2.000	2.000	2.000	2.000	2.000
M11	0.037	0.230	3.000	3.000	31.159	90.135	2.000	3.000	2.000	2.000	3.000	3.000

(*continued on next page*)

Table F.4 (*continued*)

	Environmental				Economic/Social							
	B.1.1	B.1.2	B.1.3	B.1.4	B2.1	B2.2	B2.3	B2.4	B2.5	B2.6	B2.7	B2.8
M12	0.000	0.078	5.000	5.000	26.812	88.072	4.000	4.000	2.000	2.000	4.000	5.000
M13	100.000	100.000	4.000	4.000	26.812	88.072	4.000	3.000	4.000	2.000	3.000	4.000

Table F.5
Preference function characteristics

	A.1.1	A.1.2	A.1.3	A2.1	A2.2	A2.3	A2.4	A2.5	A2.6	A2.7	A2.8	
q	1	2	1	2	2	1	1	1	1	1	1	
p	5	5	2	5	5	2	2	2	2	2	2	
	B.1.1	**B.1.2**	**B.1.3**	**B.1.4**	**B2.1**	**B2.2**	**B2.3**	**B2.4**	**B2.5**	**B2.6**	**B2.7**	**B2.8**
q	1	1	1	1	2	2	1	1	1	1	1	1
p	5	5	2	2	5	5	2	2	2	2	2	2

Table F.6
Net flows of each alternative using PROMETHEE II for each DM

	DM1	DM2	DM3	DM4	DM5	DM6	DM7	DM8	DM9	DM10
M1	0.024	0.128	0.153	−0.027	−0.319	−0.050	0.142	0.044	0.060	−0.008
M2	0.193	0.163	0.105	−0.001	−0.104	−0.055	0.148	−0.047	−0.054	−0.020
M3	−0.185	0.070	0.128	−0.022	−0.125	−0.076	−0.103	0.054	0.019	−0.108
M4	−0.066	−0.181	0.093	−0.318	0.050	−0.122	0.085	−0.431	0.068	0.031
M5	0.011	0.032	0.241	0.174	0.002	0.193	−0.059	−0.090	0.142	0.271
M6	−0.165	−0.180	−0.192	0.216	0.161	−0.059	−0.111	0.348	−0.019	−0.177
M7	−0.182	−0.018	0.054	0.208	0.056	0.022	−0.110	0.388	0.089	−0.096
M8	0.160	0.058	−0.467	0.011	0.104	−0.020	−0.056	0.037	−0.100	0.124
M9	0.147	0.032	−0.110	−0.038	0.015	−0.162	−0.075	−0.042	−0.237	0.126
M10	−0.266	−0.156	0.080	0.127	0.078	−0.074	−0.121	−0.378	−0.120	−0.226
M11	−0.162	−0.125	0.165	−0.143	−0.139	−0.025	−0.143	−0.022	0.018	−0.150
M12	0.156	0.144	0.069	−0.126	−0.160	−0.115	−0.018	−0.309	0.032	−0.124
M13	0.335	0.034	−0.320	−0.061	0.382	0.542	0.421	0.449	0.102	0.357

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