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A) Project data

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Project coordinator/ Applicant:	Austrian Institute of Economic Research – WIFO
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B) Project Overview

1 Executive Summary - German

Motivation

Sowohl die UN-Ziele für Nachhaltige Entwicklung (Sustainable Development Goals, SDGs) als auch das Klimaabkommen von Paris beinhalten ehrgeizige langfristige Ziele, die nur mit einer grundlegenden wirtschaftlichen und gesellschaftlichen Transformation erreicht werden können. In diesem Zusammenhang ist ein regelmäßiges Monitoring der Fortschritte in Hinblick auf die Zielerreichung unerlässlich und bedarf geeigneter Messsysteme. Die Komplexität der SDGs und einer Dekarbonisierung der Ökonomie erfordert den Einsatz von Indikatorsystemen anstelle von Einzelindikatoren. Das Monitoring der SDGs gemäß des UN Indikatorensets basiert auf einer Reihe von globalen Indikatoren. Diese sollen durch Indikatoren auf nationaler und regionaler Ebene ergänzt werden, die von den einzelnen Ländern entwickelt werden und deren besondere Umstände widerspiegeln (UN 2015). Dies gilt insbesondere auch für die Ziele "Erschwingliche und saubere Energie" (SDG 7) und "Klimaschutz" (SDG 13), da eine grundlegende Dekarbonisierung notwendig ist, um den Anstieg der globalen Temperatur auf deutlich unter 2°C – oder sogar 1,5°C – über dem vor-industriellen Niveau zu begrenzen, wie es im Pariser Klimaabkommen festgelegt wurde.

Ziele des Projekts

Das Projekt ClEP trägt zur Verbesserung der Messansätze im Kontext der nationalen Anforderungen aus dem Pariser Klimaabkommen und den UN SDGs bei. Die Komplexität der beiden Themen erfordert erhebliche Anstrengungen bei der Entwicklung von Indikatoren. Zu den spezifischen Zielen von ClEP gehörten unter anderem:

- Entwicklung von operationalisierbaren Indikatoren, die die Rolle von Energiedienstleistungen anstelle von Energieflüssen für das Wohlbefinden betonen;
- Fokus auf Energiedienstleistungen in Wohngebäuden, Mobilität, Industrie und dem Dienstleistungssektor;
- Berücksichtigung der drei Dimensionen der nachhaltigen Entwicklung;
- Besonderes Augenmerk auf die soziale Dimension, um das Indikatorenset durch Querschnittsthemen wie Geschlecht und Gleichstellung, Arbeitsqualität und Lebensqualität, Beteiligung und Integration zu ergänzen;
- Diskussion der Wechselwirkungen zwischen den Indikatoren und Identifikation von Synergien und Konflikten; und
- Erstellung von Composite Indices für klima- und energiepolitische Entwicklungen.

Methodik und Aktivitäten

Das Projekt ClEP gliederte sich in fünf inhaltliche Work Packages (WPs), die von einem Projektmanagement- und Disseminationsprozess begleitet wurden.

In **WP1** wurde der methodische Ansatz zur Messung eines nachhaltigen Energiesystems und zur Auswahl der relevanten Indikatoren entwickelt. Die Indikatoren decken alle Ebenen des Energiesystems (von den Energiedienstleistungen bis zur Energiebereit-stellung) und die drei Dimensionen der nachhaltigen Entwicklung ab. Darüber hinaus wurden Composite Indices entwickelt. Da insbesondere für die soziale Dimension relevante Daten weder für mehrere Länder noch als konsistente Zeitreihen verfügbar sind, wurden zwei Versionen von Composite Indices vorgeschlagen: Die Erste vergleicht die Entwicklung zwischen den Ländern im Zeitverlauf mit einem begrenzten Satz von Indikatoren, die Zweite führt einen länderübergreifenden Vergleich auf Grundlage der neuesten verfügbaren Daten für eine umfassendere Anzahl von Indikatoren durch.

WP2 untersuchte Wechselwirkungen zwischen den Indikatoren. In Anlehnung an Nilsson et al. (2016) wurden die Interdependenzen zwischen den verschiedenen Indikatoren bewertet, d.h. ob sich verschiedene Indikatoren oder Ziele verstärken oder konterkarieren, oder keine signifikanten Wechselwirkungen zeigen. Darüber hinaus wurde das ClEP-Indikatorensystem in den breiteren Kontext der UN SDGs gestellt und die wichtigsten Wechselwirkungen von SDGs 7 und 13 mit den übrigen SDGs diskutiert.

In **WP3** und **WP4** wurden die Indikatoren für neun ausgewählte EU-Mitgliedstaaten zusammengestellt. Die Länderauswahl orientierte sich an der Datenverfügbarkeit und zielte darauf ab, sowohl die nördlichen und südlichen als auch die alten und neuen Mitgliedstaaten abzudecken.

Schließlich wurde in **WP5** eine vergleichende Analyse der Performanz der Länder in Hinblick auf die energie- und klimapolitischen Indikatoren durchgeführt. Die Indikatoren wurden in einem einheitlichen Rahmen zusammengefasst. Darüber hinaus wurden die Composite Indices berechnet, einschließlich Sensitivitäts- und Dekompositionsanalysen. Die Entwicklung der Indizes in den letzten zehn Jahren wurde analysiert und es wurden Konflikte und Synergien zwischen den verschiedenen Indikatoren und Teilindizes aufgezeigt.

Ergebnisse und Schlussfolgerungen

Für das Monitoring der Transformation zu einem nachhaltigen Energiesystem ist eine umfassende Datenbasis erforderlich. Die Arbeit in ClEP zeigte, dass gerade für die soziale Dimension nachhaltiger Entwicklung relevante Indikatoren weder für mehrere Länder noch als Zeitreihen verfügbar sind. Die Composite Indices deuten nur auf moderate Verbesserungen bei der Entwicklung im Bereich Energie und Klima in den neun Ländern im Zeitraum 2005 bis 2015 hin. Einige Länder weisen jedoch, zumindest in einigen Bereichen, eine überdurchschnittliche Performanz auf. Die Analyse unterstreicht die strukturellen Unterschiede in den nationalen Energiesystemen sowie die verschiedenen Herausforderungen für eine Dekarbonisierung. Die Ergebnisse aus ClEP bestätigen zudem, dass Synergien und Konflikte zwischen den verschiedenen Zieldimensionen und den entsprechenden Indikatoren sorgfältig geprüft werden müssen. Politische Instrumente müssen daher an die nationalen Rahmenbedingungen angepasst und Interdependenzen berücksichtigt werden.

Ausblick

In zukünftigen Projekten könnte das Monitoring der Klima- und Energiepolitik durch eine Erweiterung um zusätzliche Länder und Indikatoren sowie durch eine umfassendere Bewertung der Wechselwirkungen zwischen Dimensionen, Zielen und Indikatoren weiter verbessert werden. Dies erfordert eine deutliche Verbesserung der Datenverfügbarkeit.

2 Executive Summary

Motivation

2015 was marked by the agreement on the UN Sustainable Development Goals (SDGs) and the Paris Climate Agreement. Both imply ambitious (long-term) targets which only can be met with a fundamental restructuring of economic and social systems. In this context monitoring progress towards achievement of goals is essential and needs thorough measurement systems. The complexity of the issue calls for the use of indicator systems instead of single indicators. The monitoring and review of the UN SDGs is based on a set of global indicators complemented by indicators at the national and regional level developed by the countries and reflecting their particular circumstances (General Assembly of the UN 2015). This is especially true for the goals "Affordable and Clean Energy" (SDG 7) and "Climate Action" (SDG 13), since a fundamental decarbonisation of our societies is inevitable to limit climate change to well below 2°C – or even 1.5°C – above pre-industrial levels as stated in the Paris Agreement.

Objectives of the project

The ClEP project contributes to improving measurement approaches in the context of the national requirements resulting from the Paris Climate Agreement and the UN SDGs. The research community acknowledged that the complexity inherent to these issues requires considerable efforts on indicator development (e.g. Future Earth 2016). The specific aims of ClEP included

- design of operational indicators that emphasise the role of energy services instead of energy flows for welfare;
- focus on energy services in residential buildings, mobility, manufacturing and services;
- coverage of the three dimensions of sustainable development;
- emphasis on the social dimension to complement the indicator set with cross-cutting issues such as gender and equity, quality of work and quality of life, participation and inclusion;
- discussion of interdependencies between indicators and specification of synergies and trade-offs; and
- development of composite indices for climate and energy policy progress.

Methodology and activities

The research in ClEP was structured in **five WPs** accompanied by a comprehensive project management and a dissemination process.

In **WP1** the methodological approach for measuring sustainable energy development and for selecting the indicators was developed. The indicators cover all levels of the energy system (from energy services to energy supply) and the three dimensions of sustainable development. In addition, we developed composite indices. Especially for the social dimension, relevant data are rarely available either for multiple countries or as time series. Therefore, two versions of composite indices were proposed: The first compares the development across countries and over time with a limited set of indicators, the second performs a cross-country comparison based on the latest available data for a more comprehensive set of indicators.

WP2 explored interlinkages between the indicators. Following Nilsson et al. (2016) interdependencies between the different indicators were assessed, i.e. whether different indicators or targets are reinforcing, counteracting or do not show any significant interactions. Moreover, the CIEP indicator framework was placed into the broader context of the UN SDGs and key interactions between SDGs 7 and 13 with other SDGs were highlighted.

In **WP3** and **WP4** the indicators developed for the demand-side sectors and respectively for electricity and heat supply were compiled for nine EU Member States. The country selection was led by data availability and aimed to achieve a balanced set of countries covering both Northern and Southern Member States as well as Old and New Member States.

Finally, a cross country comparison of sustainable energy development was performed in **WP5**. The indicators were summarised in a uniform framework. In addition, the composite indices were computed, including sensitivity and decomposition analyses. The development of the indices in the past decade was analysed and trade-offs and synergies between the different indicators and sub-indices were highlighted.

Results and conclusions

For monitoring the transition towards a sustainable energy system, a comprehensive database is required. Our research showed that especially for the social dimension, relevant indicators are rarely available either for multiple countries or as time series. The composite indices point at only moderate improvements in terms of sustainable energy development in the nine countries in the period 2005 to 2015. However, some countries show above-average performance, at least in some areas. The analysis underlines the structural differences in the national energy systems as well as the various challenges in the move towards decarbonisation. Research in CIEP affirms that interactions (i.e. synergies and conflicts) between the different target dimensions and the corresponding indicators need to be carefully considered. Policies have to be customised for the national circumstances, taking into account the respective interlinkages.

Outlook

In future projects, the monitoring of climate and energy policy could be further enhanced by broadening the scope by including additional countries and indicators and by assessing interactions between dimensions, targets and indicators in a more detailed and comprehensive way. This requires substantial improvements in data availability.

3 Motivation and objectives

Motivation

2015 was marked by two important outcomes of international negotiations with implications for future development: the agreement on the UN Sustainable Development Goals (SDGs) and the Paris Climate Agreement. Both imply ambitious (long-term) targets which only can be met with a fundamental restructuring of economic and social systems. The greenhouse gas (GHG) emission reductions – required to limit climate change to well below 2°C or even 1.5 °C above pre-industrial levels as stated in the Paris Climate Agreement – call for a fundamental decarbonisation of our societies. A substantial contribution to reducing emissions needs to come from the energy system since energy-related emissions account for the largest share in total GHG emissions, i.e. for 67% of Austrian and for 78% of EU GHG emissions respectively. This challenge of deep emission cuts is underpinned by the results of the IPCC Special Report on 1.5 Degrees (2018) which on the one hand emphasises the differences between a 1.5°C and a 2°C increase in temperature and on the other hand illustrates pathways how the target of 1.5°C could be achieved. The report also includes an illustration on the synergies and trade-offs between deep emission cuts and the SDGs.

Research took up the task to facilitate monitoring and implementing the 17 SDGs in a number of projects since 2015 with a focus on the interactions, synergies and trade-offs between the individual goals as well as on research in feasible development pathways (M. Nilsson et al. 2016b; Fuso Nerini et al. 2018; TWI2050 - The World in 2050 2018; McCollum et al. 2017).

For both, the Paris Agreement and the SDGs, research is challenged as the scope of the changes needed calls for new strategies and measurement and monitoring approaches. This comprises work on governance structures, pathway analyses as well as suitable indicator sets that capture the social, the economic and the environmental layer and allow depicting synergies and trade-offs among these three layers as well as between targets (TWI2050 - The World in 2050 2018; Bierman, Kanie, and Kim 2017). In this sense, indicator frameworks that go beyond the set of targets and indicators proposed by the UN are called for. The ClEP indicator system as proposed here aims at providing such an effective framework for the EU Member States that allows informed policy making and goes beyond the approaches that mainly focus on progress based on the UN indicator set (Mulholland, Dimitrova, and Hametner 2018).

Objectives of the project

The ClEP project contributed to improving measurement approaches in the context of the national requirements resulting from the Paris Climate Agreement and the UN SDGs. The research community acknowledged that the complexity inherent to these issues requires considerable efforts on indicator development (Future Earth 2016). This implies that a stepwise approach needs to be followed to cover the multidimensional aspects and that interactions between them need to be thoroughly considered. ClEP focused on developing a coherent set of energy and climate policy indicators covering the whole energy chain from energy services to energy supply as well as the three dimensions of sustainable development and thus addressed issues relevant for both, the Paris Climate Agreement and the UN SDGs, especially for the goals "Affordable and Clean Energy" (SDG 7) and "Climate Action" (SDG 13). The project combined an energy service centred perspective with research on sustainability indicators in the field of energy and climate.

The specific aims of ClEP were

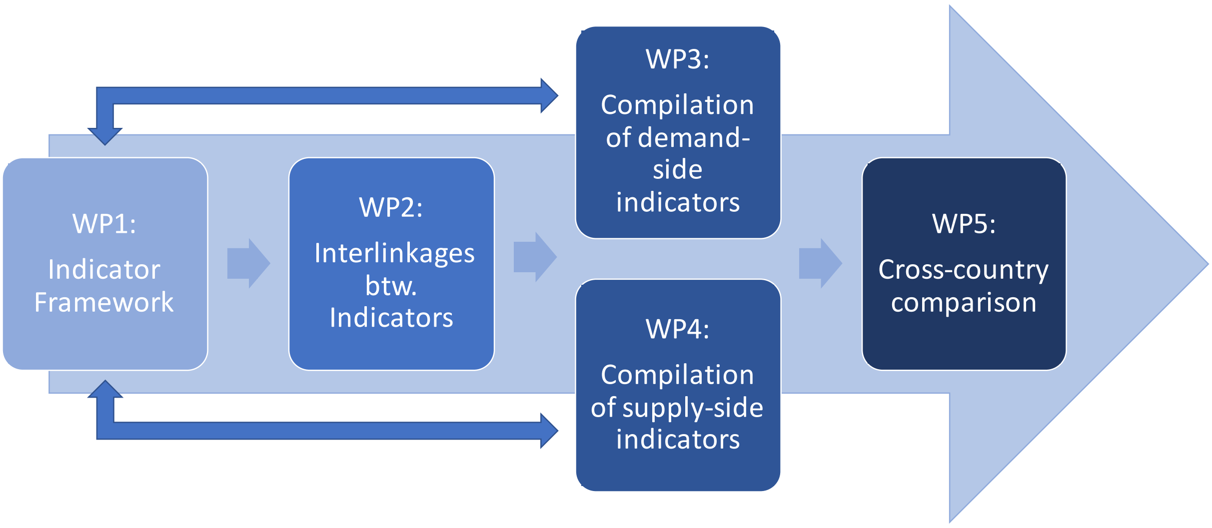
- design of operational indicators that emphasise the role of energy services instead of energy flows for welfare;
- focus on energy services in residential buildings, mobility, manufacturing and services;
- coverage of the three dimensions of sustainable development;
- emphasis on the social dimension to complement the indicator set with cross-cutting issues such as gender and equity, quality of work and quality of life, participation and inclusion;
- discussion of interdependencies between indicators and specification of synergies and trade-offs;
- development of composite indices for climate and energy policy progress; and
- embedding the ClEP indicators into a broader socio-ecological framework.

4 Content and results

Project structure and content

The CIEP project was organised in five content-related work packages (Figure 1). In the following the content and the methodology applied in each work package is briefly described.

Figure 1. CIEP project structure



WP1 Methodological approach for measuring sustainable energy development and selection of indicators

Development of consistent energy service based-indicators

The IEA and IAEA (2001) system of Sustainable Energy Development (SED) indicators and the ISED-AT framework (Kettner, Kletzan-Slamanig, and Köppl 2015b, 2015a) provide a broad range of indicators for all levels of the energy system. These indicator sets were the starting point for the development of the consistent energy service-based indicators in the CIEP project, i.e. they were the basis for choosing relevant indicators in the demand-side sectors buildings, mobility, manufacturing and services as well as for energy supply that cover the three dimensions of sustainable development. These work steps finally resulted in a set of consistent indicators that was customised for Austria and other EU Member States. The conceptual development of indicators was closely connected to a first screening of relevant databases (e.g. Odyssee database, IEA database or Eurostat) with respect to availability of appropriate data. Limited data availability (i.e. many indicators were only available for different countries and years which complicated both the selection of indicators and case study countries) required numerous iterations with WP3 and WP4 to compile the final set of indicators. The proposed indicators were validated with experts in a focus group discussion.

Development of composite indices

In addition to the indicator set, a composite index for sustainable energy development was developed. The procedure for the calculation of this sustainable energy index followed Davidsdottir et al. 2007; Ibarrarán Viniegra, Davidsdottir, and Gracida Zurita 2009; Kettner, Kletzan-Slamanig, and Köppl 2015b, 2015a).

The main advantages of calculating the composite index as well as the sub-indices are that they facilitate the monitoring of energy policy over time as interpreting and comparing many different indicators proves difficult when an overall conclusion about energy sustainability is aspired. The purpose of the composite index is to reduce the complexity, and to provide a useful instrument for policy monitoring and decision making. In addition, the index can serve as a communication tool. Through aggregating single indicators to composite indices information about specific details (e.g. sectoral developments), however, can be lost (e.g. OECD 2002, 2008). We therefore also stressed the importance of single indicators that contain important information about energy sustainability in different areas.

In total nine countries were selected for the detailed assessment of their sustainable energy development based on the indices described above. Apart from Austria, these include Denmark, France, Germany, Italy, the Netherlands, Poland, Spain and Sweden. In the selection of countries, we aimed at achieving a good mix, i.e. small and large countries, northern and southern countries as well as old and new EU Member States. Although the group of countries chosen represents a broad spectrum, eventually the selection was also determined by data availability. In order to be able to calculate the indices from the CIEP database and carry out cross-country comparisons we had to make sure that the for the selected group of countries the major part of the indicators required was available.

WP2 Interlinkages between Indicators

In the context of the SDGs interactions between the 17 headline goals as well as between different targets are intensely discussed (see e.g Måns Nilsson, Griggs, and Visbeck 2016; M. Nilsson et al. 2016a; TWI2050 - The World in 2050 2018). The SDGs implicitly depend on each other, but the interlinkages between the different goals and indicators had not yet been examined in detail upon their adoption. When overlaps between targets are ignored, there is a risk of perverse outcomes. This does not only hold true for the broad scope of the SGDs, but also for the energy and climate policy indicators developed in CIEP. For instance, policies aiming at reducing energy expenditures of poor households (and therefore contributing to improvements in the social dimension) might increase energy demand and in turn emissions (with negative effects on the environmental dimension) if not properly designed.

In CIEP therefore special emphasis was put on interactions between the compiled indicators. Following Nilsson et al. (2016b) interdependencies between the indicators were assessed, i.e. whether different indicators or targets are reinforcing or counteracting or do not show any significant interactions. Moreover, the CIEP indicator framework was placed into the broader context of the UN SDGs and key interactions between SDGs 7 and 13 with other SDGs were highlighted.

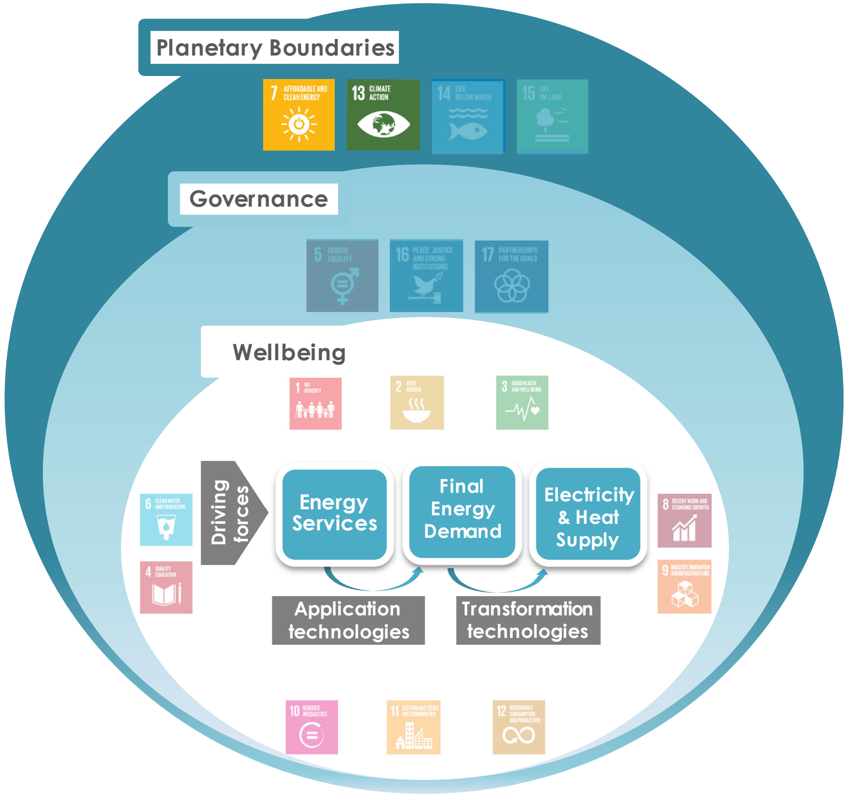
Figure 2(a) presents a conceptual illustration for a better understanding of the interlinkages between the SDGs. The 17 SDGs are embedded into a broader socio-ecological context. The figure illustrates the three layers to which the SDGs can be assigned or for which they are of particular relevance – wellbeing, governance and planetary boundaries; in this sense the approach is based on TWI2050 - The World in 2050 (2018) and Kettner, Köppl, and Stagl (2014). This combination of the concept of wellbeing and the concept of planetary boundaries creates a space in which sustainable development can be achieved, i.e. to meet social goals while at the same time sustaining the integrity of ecosystems is preserved so that they can provide the services on which our societies depend. In this representation we defined ten SDGs to pertain to the layer of wellbeing. These are embedded in governance structures (including three SDGs) that constitute the supporting structures for wellbeing. The outermost layer are the planetary boundaries representing the bio-physical base as well as the natural limits for all societal processes and activities. Climate change and its impacts, for instance, are relevant for the successful implementation of all SDGs.

Figure 2(b) illustrates how the energy service approach that represents the basis for the ClEP indicator set relates to this socio-ecological framework and the SDGs. While the issues of energy and climate change pertain to the layer of "planetary boundaries", energy services, that are the starting point for our indicator framework, are an integral part of the layer representing "wellbeing".

Figure 2. Socio-ecological context

(a) Embedding the SDGs into the broader socio-ecological context

(b) Embedding the CIEP indicator approach into the broader socio-ecological context



WP3 Compilation of Demand-Side Indicators

The main contribution of WP3 was to compile the indicators defined for the demand side for a selection of EU Member States. We focused on four major areas of final energy demand and GHG emissions: mobility, buildings, manufacturing and services. The energy-related greenhouse gas emissions of these sectors account for 62% of Austrian GHG emissions and 83% of EU GHG emissions respectively.

Diverse databases were used to compile the demand-side indicators. Proxy data for energy services, i.e. the floor area of dwellings, passenger and freight transport performance and gross value added of the manufacturing and service sectors, as well as the related efficiency data were derived from the Odyssee database. The number of households, information on the different capital stocks and equipment rates as well as the sectoral shares of renewable energy sources are also from this database. Sectoral GHG emissions were taken from the UNFCCC's National Inventory Reports, data on newly registered vehicles are from the European Environment Agency's databases. Household income and expenditure is from Eurostat, energy prices and sectoral public energy expenditure are from the IEA. Complimentary information on sectoral patenting activity was taken from the OECD's EPO database.

WP4 Compilation of Supply-Side Indicators

In contrast to the demand-side sectors, electricity and heat supply is only indirectly related to energy services. Final energy demand from residential buildings, mobility, manufacturing and services determines the energy input required to supply power and heat. Thus, emissions are a result of the transformation technologies used (plant types), the fuel mix and the level of final demand to be satisfied. The structure of energy indicators for this sector hence deviates from the demand-side sectors.

As for the demand-side sectors, various databases were used to compile these indicators. Data on energy flows, i.e. final energy demand, transformation input and transformation output by energy source, were taken from the IEA's Energy Balances. Plant capacity, energy prices and public energy R&D expenditures were also derived from IEA databases. Emission data were taken from the UNFCCC National Inventory Reports and data on the social dimension are from Eurostat, i.e. from the Structure of Earnings Survey, the Labour Force Survey and the European Statistics on accidents at work.

WP5 Cross-Country Comparison

In the final work step the indicators developed in WP1 and compiled in WP3 and WP4 were summarised in a uniform framework. In addition, the sub-indices for the five different areas – mobility, housing, manufacturing, services, electricity and heat supply – and the three dimensions of sustainable development as well as the aggregate index defined in WP1 were provided for selected EU Member States. For each of the composite indices sensitivity analyses (i.e. inclusion of additional indicators, corrections for variable electricity generation from renewable energy sources, alternative weighting factors) and decomposition analyses were performed. This ensures the quality of the composite indices on the one hand and allows highlighting the impact of changes in individual indicators on the other hand.

The development of the different indices in the past decade (i.e. between 2005 and 2015) was assessed for nine selected EU Member States, highlighting trade-offs and synergies between the different indicators and sub-indices. For the best performing countries an appraisal of underlying policies was performed, and lessons learned were drawn for Austria.

Results and project milestones

WP1 Methodological approach for measuring sustainable energy development and selection of indicators

The structure of the CIEP indicator framework for monitoring energy and climate policy is illustrated in Figure 3. For each of the five sectors, the indicators are arranged in five modules, comprising context indicators, energy service indicators as well as energy system indicators covering the three dimensions of sustainable development. Context indicators include for instance average household size, energy prices or heating degree days (HDDs). For the demand side-sectors, indicators for the economic dimension include the efficiency of energy service provision (i.e. the energy service proxy divided by final energy consumption), energy costs as well as patents related to energy efficiency. Economic indicators for electricity and heat supply capture transformation and distribution efficiency as well as energy technology patents and public energy R&D expenditures. The environmental dimension covers the share of renewable energy sources as well as CO_2, NO_x and SO_2 emissions and intensities for all sectors. With respect to the social dimension, indicators have been developed for the sectors residential buildings, transport and electricity and heat supply. These indicators cover i.a. the affordability of energy-related appliances and comfortable room temperature, household equipment rates with certain appliances, differences in the shares of energy costs in household expenditure by income quintiles or the share of electric and alternative vehicles in new registrations for the demand side sectors.

As noted above, the structure of energy indicators for electricity and heat supply deviates from the demand-side sectors, since energy supply is only indirectly related to energy services. Final energy demand from residential buildings, mobility, manufacturing and services determines the energy input required to supply power and heat. Thus, emissions are a result of the transformation technologies used (plant types), the fuel mix and the level of energy services that has to be satisfied. The social indicators for energy supply include the gender pay and employment gap, wage issues and work health aspects in the energy supply sector. The list of indicators is provided in Annex 1 to this report.

Figure 3. Structure of the CIEP indicator framework

Dimen-sion / Sector	Residential Buildings	Mobility		Industry	Services	Electricity & Heat
		Passengers	Goods			
Drivers / Context						
Energy Services						
Energy System Indicators						
Economic						
Ecological						
Social						

For the composite indices, we initially selected 30 indicators that are shown in black in Table 1. 14 indicators can be assigned to the ecologic dimension, 13 to the economic dimension and 3 to the social dimension. In terms of sectoral disaggregation, 10 indicators apply to the household sector, 7 to the transport sector, 4 each to the industry and service sector and 1 to electricity and heat supply.

As explained above, because of data limitations particularly for the social dimension an additional extended version of the index was calculated including also indicators that are only available for individual years (in total 42 indicators). These indicators are displayed in grey in Table 1. For the extended index, 13 indicators can be assigned to the residential sector, 12 to transport and 9 to electricity and heat supply; for industry and services again the same 4 indicators were used. When grouped by dimension of sustainable development, 15 indicators refer to the ecological dimension, 14 to the economic dimension and 13 to the social dimension.

The indicators for the composite index were selected to provide information on the different levels of the energy system as illustrated above and on all dimensions of sustainable energy development. Changes in the energy service proxies were not included in the index, since they cannot be interpreted in an unambiguous way (i.e. an improvement in energy efficiency, for instance, will always be beneficial for sustainability while this is not straightforward for an increase in the stock of appliances). Furthermore, the indicators should be characterised by good data availability and quality.

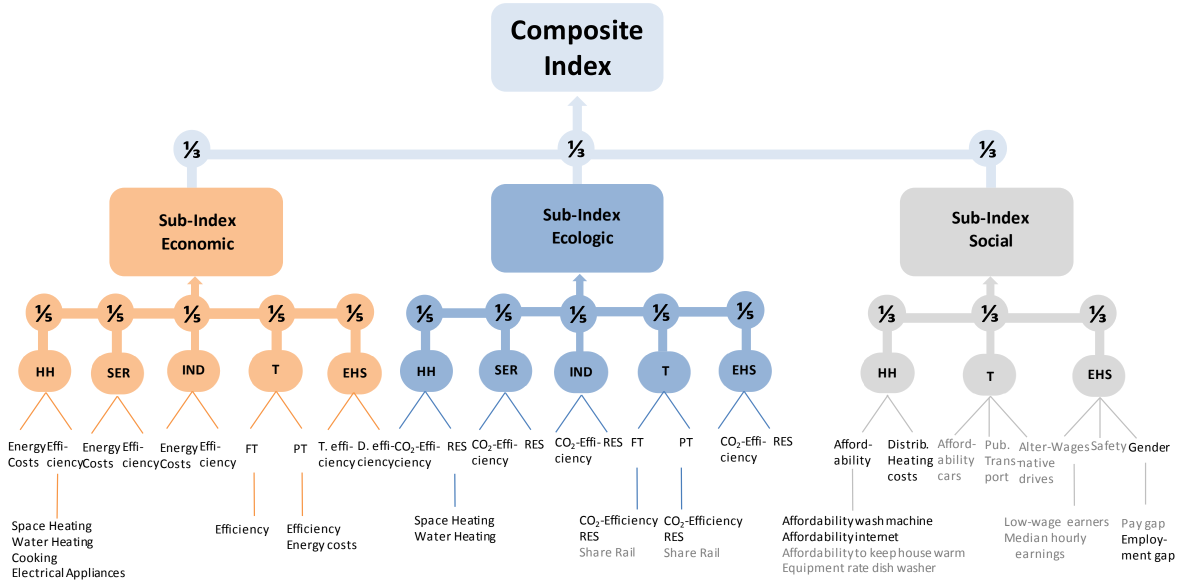
Table 1. List of indicators to be included in the composite indices

	Residential	Transport Passenger T.	Transport Freight T.	Industry	Services	Electricity and Heat Supply
Economic	Energy efficiency by use category Energy cost share	Energy efficiency Energy cost share	Energy efficiency	Energy efficiency Energy cost share	Energy efficiency Energy cost share	Transformation efficiency Distribution efficiency
Environ-mental	Share of RES CO_2 Efficiency	Share of RES CO_2 Efficiency Share Rail in MS	Share of RES CO_2 Efficiency Share Rail in MS	Share of RES CO_2 Efficiency	Share of RES CO_2 Efficiency	Share of RES CO_2 Efficiency
Social	Affordability of washing machine Affordability to keep the house warm Affordability of internet connection Equipment rate of dishwashers Share of heating costs in HH income	Share of alternative drives in new registrations Accessibility of public transport Affordability of cars				Low wage earners Median hourly earnings Fatal incidents Gender pay gap Gender employment gap

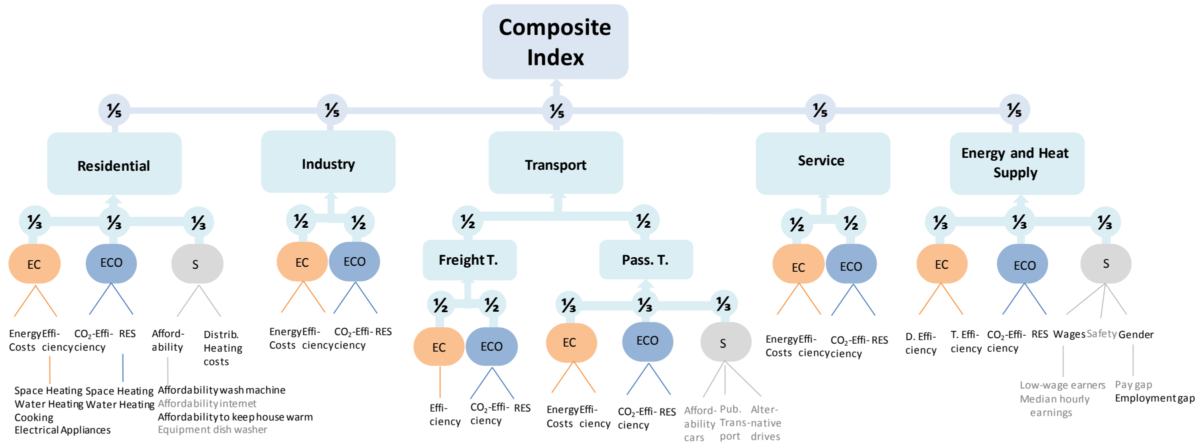
Figure 4 illustrates the way in which the indicators were aggregated for calculating the sectoral and dimensional sub-indices and finally the composite index. The different composition of the sub-indices thus determines the weight of the individual indicators in the calculation of the composite index and thus explains the disparity in the total values.

Figure 4. Aggregation structure of the composite indices

(a) Aggregation by sector and dimension



(b) Aggregation by dimension and sector



WP2 Interlinkages between Indicators

The intense discussions regarding the manifold interactions between the 17 headline goals as well as between different targets (Måns Nilsson, Griggs, and Visbeck 2016; M. Nilsson et al. 2016a; McCollum et al. 2017; TWI2050 - The World in 2050 2018) is taken up in Figure 5. The SDGs implicitly depend on each other, but the nature of the interlinkages between the different goals and indicators are still a broad research area. This is of high relevance, since ignoring overlaps, synergies or trade-offs between targets bears a risk of perverse outcomes. This does not only hold true for the broad scope of the SGDs, but also for the set of the CIEP energy and climate policy indicators as described below. Figure 5 illustrates which thematic areas of SDGs 7 and 13 we identified as being strongly or directly linked to eleven other goals and which interactions between these objectives must be considered to achieve the targets and design adequate monitoring approaches. For instance, policies aiming at reducing energy expenditures of poor households (and therefore contributing to improvements in the social dimension / SDG 10) might increase energy demand and in turn emissions (with negative effects on the environmental dimension / SDG 13) if not properly designed.

Figure 5. Interaction of the SDGs "Climate Action" and "Affordable and Clean Energy" with other SDGs

Starting from this broader view on the SDGs, the focus was put on SDG7 and SDG13 for which we developed the ClEP indicator set. We embedded the ClEP indicators into a broader socio-ecological framework which is defined by the UN SDGs (see also Figure 2 above).

Given the importance of interacting SDGs and sub-targets we attempted to indicate the relationship between the energy service-focussed ClEP indicators and the broader context of the SDGs. For example, when integrating the social dimension in the ClEP climate and energy policy indicator set, the focus on the energy supply side is on the quality of employment, and on the energy demand side the focus is on daily conduct of life practices in private households (Magistratsabteilung 18 – Stadtentwicklung und Stadtplanung 2015). Cross-cutting issues that are relevant for all areas and at the same time highlight the relation to some other SDGs are identified: gender equality and gender equity[1] (Röhr 2008) – both for energy supply and energy demand (Räty and Carlsson-Kanyama 2010), increasing the quality of employment (on the energy supply side) and respectively quality of life (on the demand side) as well as participation on the energy supply side or inclusion on the energy demand side. This exercise brings sobering findings due to the uncertainty in predicting how particular future trends affect everyday life, consumption and mobility behaviours as well.

Reflecting the outcomes makes the multidimensionality and the ambivalences of the different dimensions visible, in particular as a consequence of the inclusion of the social dimension. For example, an increase in physical assets such as household appliances and

[1] Cf. about the concept of gender equality (Pimminger 2017, 2017).

vehicles may mean a reduction of social inequality and / or an increase in mobility, but at the same time can have a negative impact on the environment.

Table 2 exemplifies interactions between different indicators. Trade-offs become visible between the different SDGs. Depending on the underlying assumptions, different development paths are conceivable which then however would end in different assessments of their effects. The evaluation of interactions follows Nilsson et al. (2018) and ranges from -3 to +3: -3 denotes cancelling targets while +3 denotes indivisible targets. A more comprehensive analysis of interactions between indicators is provided in Annex 3 to this report.

Table 2. Interdependence table of social indicators and their impact on the SDGs

CIEP	Indicators	Social							
		Population able to keep home adequately warm				New registrations of EL, AIT passenger cars			
		7 Affordable and clean energy	5 Geschlechtergleichheit	13 Climate action	Treibhaus gas-Reduktion	7 Affordable and clean energy	5 Geschlechtergleichheit	13 Climate action	Treibhaus gas-Reduktion
Social	Low-wage earners	-2	-2	1	2	-1	-1	1	1
	Gender employment gap	1	1	1/-1	-1	1	2	1/-1	1

The work in WP1 and WP2 has been described in a joint working paper "Monitoring Sustainable Development: Climate and Energy Policy Indicators" (Kettner et al., 2018).

WP3 Compilation of Demand-Side Indicators

For the four demand-side sectors a set of 118 high-level energy indicators has been compiled. These indicators can be further disaggregated to about 387 indicators. The list of indicators can be found in Annex 1 to this report, a detailed overview of the data sources used is provided in Annex 2. In addition, the database covering the indicators for the nine selected EU Member States can be downloaded at the project website www.clep.wifo.ac.at.

Data availability was quite good with respect to indicators describing the economic and ecological dimensions. For the transport sector it must be noted, however, that the statistical data available are limited to motorised transport. Additional data on non-motorised transport (e.g. with respect to distances travelled or infrastructure) would be needed to gain more meaningful insights on structural changes in mobility. Concerning the industry and service sectors a differentiation of useful energy categories such as those included in the Austrian energy balances would allow a more in-depth analysis[2]. In addition, life cycle emissions of the different technologies would deliver valuable insights.

The gap between the conceptual perspective of the social dimension and the availability of data is more pronounced. Considering the scarcity of crosscutting data, we proposed two category groups to depict the social dimension of energy services (1) energy poverty and (2) mobility. For energy poverty, the affordability of home appliances and consumer

[2] The Austrian balances of useful energy distinguishes between seven categories of use: space heating and air condition, steam production, industrial furnaces, stationary engines, traction, lighting and computing and electrochemical purposes. Information on final energy consumption by energy use category is available for 20 (sub-sectors) and differentiated by energy source.

electronics, as well as households' heating costs, were used as indicators (Brunner et al. 2012, Brunner et al. 2017), or, more precisely, the potential risk of energy poverty. Mobility is indicated, first, by vehicle availability by type of fuel (gasoline, diesel / electrical energy / alternative energy) and public transport availability expressed as difficulty in having access to public transport, and, second, by mobility affordability in terms of passenger cars. Again, an extended data availability on i.a. non-motorised individual transport (cycling and walking), public transport and mobility infrastructure (accessibility of public transport stations and stops, availability of rent-a-bike stations and car-sharing locations) would allow better insights in private households' daily conduct of life (Lebensführung) including mobility behaviour with respect to the cross-cutting issues "gender & equity", "quality of life" and "inclusion". In terms of mobility, for example, data about bicycle availability per household, ownership of season ticket for public transport, annual distance covered by foot, by bicycle, distances per main transport mode (modal split) by gender etc. would be useful but is not available at national level. The STEP25[3] report provides first approaches for Vienna on how such a measurement might look like.

WP4 Compilation of Supply-Side Indicators

For electricity and heat supply a set of 25 energy indicators has been compiled providing an aggregate view on the sector. These indicators can be further disaggregated to about 130 indicators differentiating by energy source and plant type. The list of indicators can be found in Annex 1 to this report, a detailed overview of the data sources used is provided in Annex 2. In addition, the database covering the indicators for the nine selected EU Member States can be downloaded at the project website www.clep.wifo.ac.at.

As for the demand-side sectors, data availability for the supply side was also relatively good for the economic and ecological dimension. Nevertheless, data on the costs would provide valuable information with respect to the economic dimension, e.g. the levelised costs of energy generation. Just as for the demand side, information on life cycle emissions and other environmental effects (e.g. land use, water use, etc.) would be desirable to get a more comprehensive view of the environmental dimension.

To depict the social dimension for the supply side sector is again more challenging. Based on well-founded concepts of evaluation of the quality of employment such as the "DGB-Index Gute Arbeit", the "decent work" concept of the International Labour Organisation (ILO) (UNDP 2015) and Eurostat's research on European "working conditions" and matched with the data availability, four categories were defined in ClEP to depict the work conditions on the energy supply side: (1) income and benefits from employment, (2) temporary employment, (3) health and safety at workplace, (4) work-life-balance. Gender-specific differences in employment and wages serve as indicators for equality of opportunity (Cohen 2017; Beate Littig 2017; B. Littig and Zielinska 2017). Here again the limited availability of data must be considered. It would be desirable to have extended statistics, some of which already exist, on the national level, which would allow a broader and detailed international comparison of quality of employment in the energy sector with regard to compatibility of family and career (unpaid work by gender, atypical and long working hours, flexibility of the work schedule), satisfaction with commuting time, invol-

3 Cf. Magistratsabteilung 18 – Stadtentwicklung und Stadtplanung (2015).

untary temporary contracts, work-related health problems (physical wellbeing as well as mental wellbeing) and job satisfaction.

WP5 Cross-Country Comparison

In WP5 the indicators have been presented in a uniform framework. In addition, the composite indices – including decomposition and sensitivity analysis – were calculated and based on a country review lessons learnt were addressed. The results of WP5 have been published in a working paper "Monitoring Sustainable Energy Development: A cross-country comparison of selected EU Members" (Kettner et al., 2019).

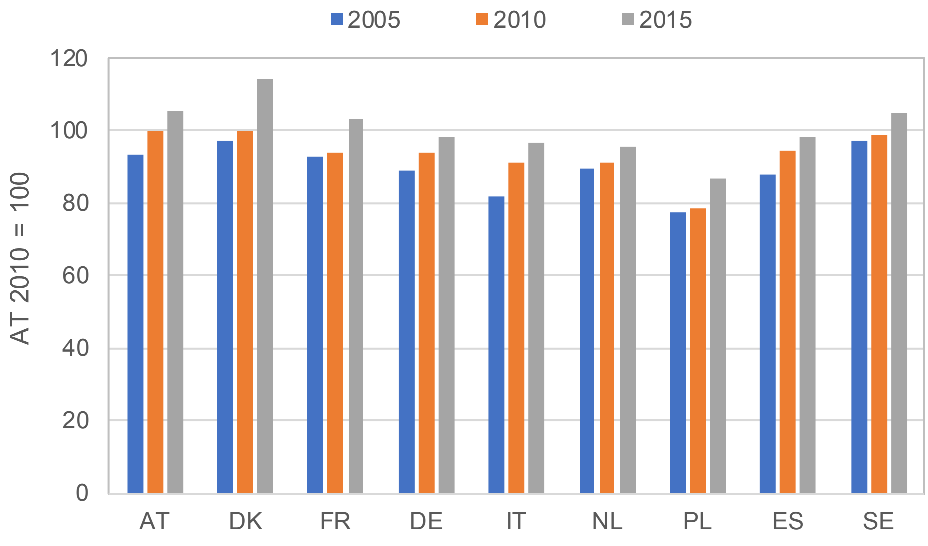
Composite Indices

In addition to the comprehensive indicator framework, complementary composite indices were developed in ClEP to monitor overall sustainable energy development in the selected nine EU Member States.

For the cross-country comparison over time, the index was normalised with the figures for Austria in 2010 equals 100. Using this distance to reference country approach the development in all countries is measured against this benchmark, i.e. the focus is on how one country performs compared to others and how the countries' performance changes over time.

Figure 6 summarises the development of the composite index aggregated by dimension using equal weights for all indicators. Between 2005 and 2015 the composite index increases for all countries, albeit on different levels. While in the first year 2005 two countries (Denmark, Sweden) ranked higher than Austria, due to different rates of change in 2015 only Denmark shows a higher value than Austria (with Sweden close behind). Although starting from a high level, Denmark managed to improve its position significantly over time (+17%). In both years France holds the 4th rank. Another group of countries (Germany, Netherland, Italy, Spain) achieve figures that are 8 to 10 points below Austria in both years. Of these countries Italy shows the largest improvements over time, closing the gap on countries like Germany or the Netherlands. Clearly lagging behind is Poland, although this country – together with Spain – shows one of the highest increases in the index over time (12%). However, by and large the increase is not sufficient for Poland to catch up with the other EU countries. Another aspect worth noting is the temporal distribution of improvements. In some countries (most notably Denmark, France, Poland, Sweden) the advances in sustainability mainly occurred after 2010, while in others (Germany, Austria, Italy) the upward trend was stronger before 2010.

Figure 6. The composite index aggregated by dimension, 2005, 2010 and 2015



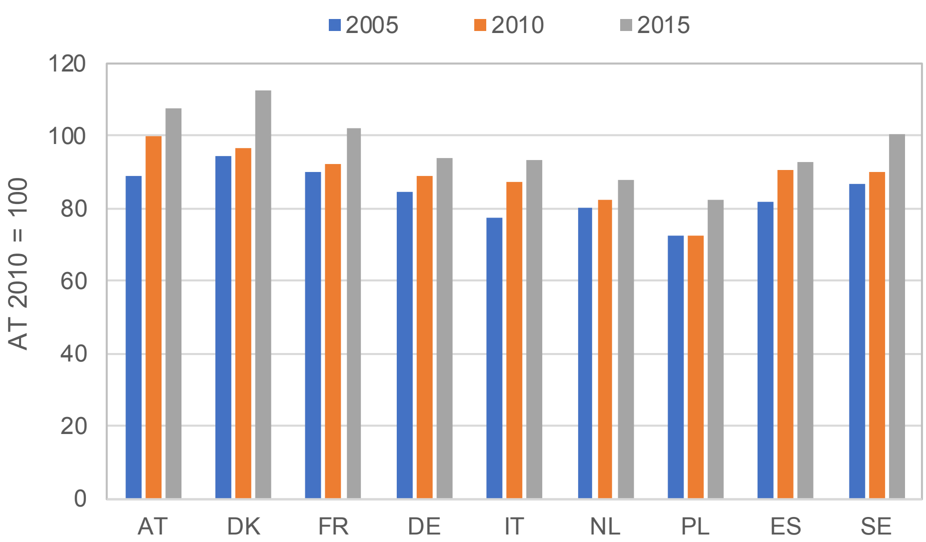
When taking a closer look at the developments in the three dimensions per country (see WP2), it stands out that the strongest dynamic arises in the ecological dimension, i.e. caused by rising shares of renewables and improved CO_2 efficiency. Especially Austria, Italy, Denmark, France and Spain show pronounced improvements, although the patterns of change are divergent. While for instance Austria improved quite rapidly until 2010, after that the development stagnated. In contrast, the improvements in Denmark were more continuous, whereas Italy and Spain achieved some catching up in the ecological dimension but have still not achieved a high level of environmental sustainability in their energy systems. Sweden showed little but continuous improvements but had the highest ecological sustainability level from the outset. On the other end of the scale we find countries like Poland, the Netherlands and Spain with low to medium improvements and still low levels of ecological sustainability.

Compared to the ecological dimension little dynamic can be seen in the economic and social dimensions. In the former, this hints at a lack of significant improvements in energy efficiency, except for Sweden, that stands out in this regard with an increase that is twice as high as the one achieved by Denmark, which is also above average. However, this can be interpreted as a catching up process as Sweden starts out with a comparably low level of economic sustainability. With respect to the social dimension, improvements are generally modest. Contrary developments occurred in Austria and Sweden, which show a decrease in social sustainability. This is mainly due to the prevailing gender employment gap in the energy supply sector.

For the sectoral aggregation the overall development (using equal weights) is depicted in Figure 7. The general pattern and positive development conform to the dimensional aggregation. Also, the four best performing countries remain the same (Austria, Denmark, France and Sweden). In this case, however, Sweden does not perform as well (rank 4), it shows more of a catching up development. The medium performers consist of three countries in this analysis (Germany, Italy and Spain). The Netherlands in turn are in this case closer to Poland, which brings up the rear.

Compared to the dimensional perspective the improvements are moderate when taking into account the five sectors. Very little improvements (in terms of efficiencies and share of renewables) can be detected in the residential sector. Interestingly, in this area Sweden shows a similar low level of sustainability as Poland. This might, however, be due to the rather large share of electricity in heating. In transport the dynamics are a little bit stronger – especially France improves considerably. In contrast, in Sweden and Germany the sub-index remains largely unchanged. The other countries achieved low to medium continuous improvements (starting from diverging levels of sustainability). The exceptions are Austria (with improvements only until 2010) and Denmark (improvements after 2010). In general, industry shows the strongest positive dynamic of all the sectors. However, the patterns of development differ between the countries. While Austria, the Netherlands and Germany are basically stagnating in terms of industrial sustainability, other countries improve considerably. Especially Denmark manages to improve from an already high level of sustainability. This holds true also for Sweden, although on a somewhat lower level. Countries like Spain and Italy make good progress in catching up. The service sector in contrast remains practically unchanged with little to no improvements. The only exceptions are Austria with considerable efficiency improvements and Sweden with continuous but slightly lesser progress. The sub-index for energy supply is largely stagnating. Only Denmark and Italy achieved increases in sustainability. Poland and Spain manage some catching up but remain under average. This leads to the conclusions that the efforts to increase the share of renewables in electricity generation have not yet paid off in this respect. However, for countries with high renewables shares from the outset (e.g. Austria or Sweden) significant improvements are difficult to achieve. In other countries, especially those with a high share of nuclear energy there is also strong inertia in the energy market.

Figure 7. The composite index aggregated by sector, 2005, 2010 and 2015



Sensitivity Analysis

To check the stability of the index and the results we carried out several sensitivity analyses. The first approach was to use alternative weighting factors in the aggregation of the indices, i.e. we used the sectors' relative shares in CO_2 emissions as weights.

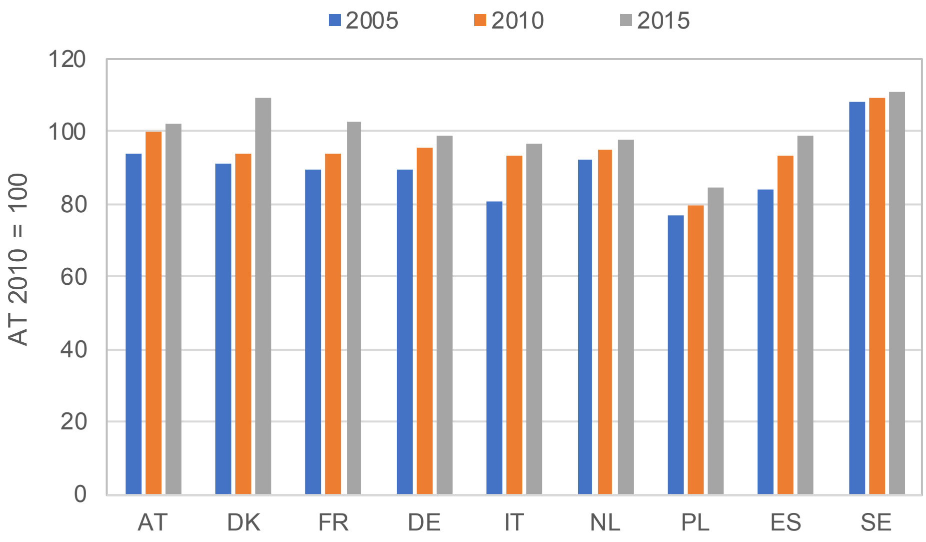
In addition, an extended database was used to calculate the indices for 2015. Some indicators – especially regarding the social dimension – are not available for the whole period. But we regarded this information as important for emphasising the social aspects in relation to energy development as this is usually largely blended out in energy analyses. This sensitivity analysis thus focussed on checking these indicators' influence on the aggregate outcome.

Finally, we corrected for fluctuations in electricity generation from variable renewable energy sources (smoothed as proposed by the EU's Renewable Energy Directive). The results from this analysis are not shown separately here as they are almost identical to the baseline case.

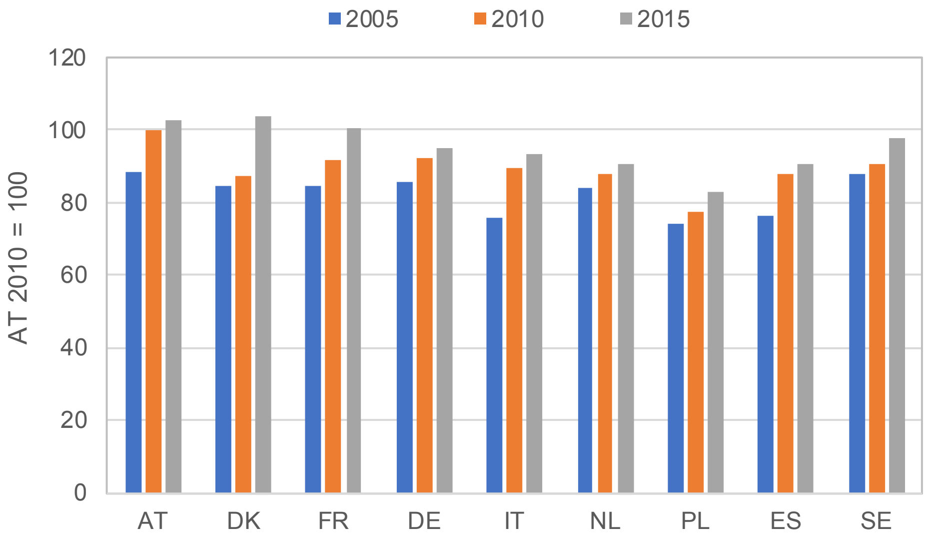
Using the alternative weighting approach (weighting by CO_2 emissions) the overall picture remains largely the same regarding the general positive trend as well as the leading and lagging countries. Also, the rates of change differ only marginally. The single noticeable difference is that the decrease in social sustainability in Sweden is even more pronounced.

Figure 8. The composite index with alternative weighting factors, 2005, 2010 and 2015

(a) Aggregated by dimension



(b) Aggregated by sector



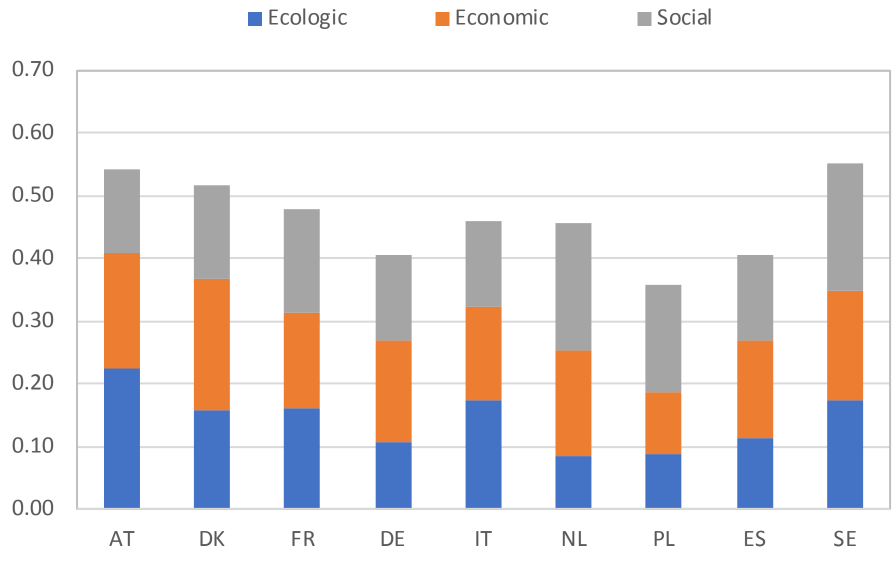
The results of the approach with equal weights show an overall upward trend for the countries covered by the index over the whole period 2005 to 2015. This points at a continuous improvement towards a more sustainable energy system. In some cases, "real" progress can be observed – e.g. when a country achieves significant improvements despite starting from an already comparatively high level of sustainability. In other cases, the improvements are more in line with a catching up process towards other, more sustainable countries.

Weighting the sectors by their shares in CO_2 emissions does not considerably change the aggregate results. The ranking of countries according to the level of sustainability achieved in 2015 remains largely constant. In addition, also the sectoral sub-indices do not change significantly. In some cases, the more pronounced effects observed in the analysis using equal weights – especially the strong positive development in the service sectors of Austria and Sweden – are alleviated and now conform to the only marginal improvements stated for the other countries. In turn, the weight of the transport sector increases further as the improvements over time result twice as high in Austria, France and Spain. Also, the sector energy supply increases its sustainability at a significantly higher rate in Denmark and Germany. These results show the importance of these two sectors which are on average responsible for two thirds of the CO_2 emissions.

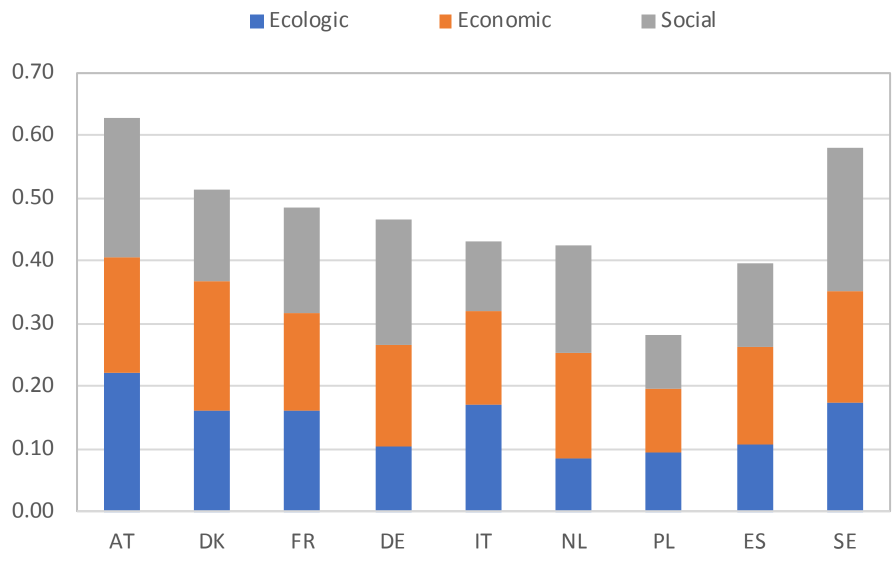
For an extended set of indicators (as summarised in Table 1), including data that are not available for the whole period but that are regarded as important for assessing sustainable energy development an adjusted index was calculated based on 2015 or respectively the last available year only. In Figure 9, the composite indices using the extended approach (a) and the 2015 results from calculating the composite index according to the Min-Max methodology with the fewer indicators used already for the time series analysis (b) are compared.

Figure 9. An extended composite index based on the Min-Max methodology, 2015

(a) The extended composite index by dimension



(b) The standard composite index by dimension – Min-Max methodology



The main differences can be summarised as follows: in general, the greater number of indicators – especially related to the social dimension – reduces the spread in the index values between countries. It also leads to a decrease in the index values in Austria, Germany and Sweden. This results in a shift in the ranking of countries – Sweden and Austria change places (Austria falls from first to second rank), Germany loses two positions. In other countries (Italy, the Netherlands and Poland) the additional indicators lead to increases in the index. This hints at a relatively better performance in terms of the social dimension in these countries.

The first conclusions that can be drawn is that if only one single year is analysed there are no significant changes in the overall ranking of countries or the composition of country groups (top performers Austria, Denmark, France, Sweden; medium performers Germany, Italy, the Netherlands, Spain; taillight Poland) as compared to the results for 2015 from the time series analysis. However, the altered composition of the indicator set and the more comprehensive database deliver some changes at the sub-index level.

Lessons (to be) learnt

First, in general the improvements regarding energy efficiency, emissions and deployment of renewables have been moderate in the period under observation. This hints at the time needed for the energy transition to take place. Mainly the countries with a long tradition in ambitious environmental and climate policy making show above average developments – at least in some areas. These are mainly the Nordic countries that also have comprehensive social security systems in place. In contrast, Poland still focusses its energy policy on coal and will continue to do so. Positive developments regarding the deployment of renewables seem to have happened despite rather than because of energy or climate policy. The country comparison underlines the importance of credible political commitment to climate targets, the implementation of ambitious instruments and the need for stability in the guiding frameworks for decarbonisation to be successful. However, the costs of climate policy measures (particularly in the context of differing income levels) have to be accounted for and potentially mitigated by targeted compensation mechanisms for low income households. These considerations become more relevant as cheap mitigation or efficiency options are exhausted.

5 Conclusions and recommendations

Findings derived in the project

The UN SDGs and the Paris Climate Agreement both imply ambitious (long-term) targets which only can be met with a fundamental restructuring of economic and social systems. In this context monitoring of progress towards achievement of goals is essential and needs thorough measurement systems.

The complexity calls for indicator systems instead of single indicators. While the list of indicators proposed to monitor the 17 SDGs and the corresponding 169 targets is already very comprehensive, for monitoring and steering of policy more detailed indicator sets for individual SDGs are required. Moreover, it was suggested to complement the UN indicator set by operational indicators at the national and regional level to be developed by the countries and reflecting their particular circumstances (UNFCCC 2015). Against this background we propose a set of indicators that allow monitoring of progress towards energy and climate policy targets in the EU context.

We combine the energy service perspective with research on sustainable energy development indicators and apply this approach in the broader context of the SDGs. Furthermore, we put emphasis on the consideration of the social dimension and the development of meaningful indicators.

The conceptual development of indicators was closely connected to a first screening of relevant databases (e.g. Odyssee database, IEA database or Eurostat) with respect to the availability of appropriate data. Limited data availability (i.e. many indicators are not available for all countries and years) required iterations to compile the final set of indicators.

Data availability was acceptable for the economic and ecological dimension but is limited for the social dimension. Thus, additional information would be required in order to comprehensively track changes in energy use patterns. Apart from gaps in the available datasets – especially, but not only, for the new EU Member States it is not possible to compile a longer time series – there are additional data or indicators that would be of value for our analysis like efficiencies of appliances that go beyond the available data and allow to disaggregate the effect of usage time from technical efficiency, non-motorised transport, use categories for final energy demand, investment costs, levelised costs of generation, life cycle emissions and other environmental effects (e.g. land use, water use, etc.). Comprehensive data about energy poverty and mobility behaviour as well as about the quality of employment at sectoral level are also desirable.

The sustainable energy indicators proposed in CIEP cover the three dimensions of sustainability. As for the SDGs, interactions (i.e. synergies and conflicts) between the different target dimensions and the corresponding indicators need to be carefully considered.

Given the complexity of the issue and the gaps in data availability/adequate indicators it is difficult to interpret certain observable trends. For instance, an increase in electric cars can be both beneficial or detrimental from an environmental point of view, depending on whether these cars are substitutes for fossil fuel powered cars or additional vehicles. The opposite applies for the social dimension as a larger number of cars increases the mobility options available for individuals. However, the net effect on mobility is again impossible to assess as no data on non-motorised transport are available. This needs to be kept in mind when using the indicator system for policy analysis.

However, the analysis of the composite indices for sustainable energy development for the selected countries delivers several results. First, in general the improvements regarding energy efficiency, emissions and deployment of renewables have been moderate in the period under observation. This hints at the time needed for restructuring to take place. Some countries showed above average positive developments. These are mainly countries that have a long tradition in ambitious environmental and climate policy making and are also renowned for their social security systems (e.g. Denmark, Sweden). In contrast, Poland still focusses its energy policy on coal and will continue to do so. Deployment of renewables or emission mitigation is mainly being regarded as a necessary exercise to fulfil requirements posed by the EU. Positive developments, e.g. regarding the increase in renewables, can be regarded as unintended developments rather than because of targeted Polish energy policy making. This underlines the importance of credible political commitment to climate targets, the implementation of ambitious instruments and the need for stability in the guiding frameworks in order to effectuate substantial changes. However, the costs of climate policy measures have to be taken into account, especially with regard to effects on low income households targeted compensation mechanisms have to be developed.

Further steps that will be taken by the project team

One key issue related to sustainable development is the multidimensionality and the resulting trade-offs and synergies between different sub-targets reflected in the indicators. The results obtained in ClEP can be used to refine the methodological approach to analyse these interlinkages in more detail. In future research additional emphasis will be laid on the trade-offs and synergies between decarbonisation and social impacts.

Relevance for other target groups

In the project we developed a comprehensive database for the monitoring and evaluation of energy and climate policies with special emphasis on social aspects of energy development. It became clear that for a series of issues no data (at present) are available and have thus to be omitted from the analysis. The closing of the gap has to be spurred by policy makers (in providing the legal basis for data collection) and statistical offices in actual data collection and processing.

The main uses for such a comprehensive database as ours and resulting indices are:

- Help policy makers define measurable goals and strategies;
- Provide an evidence base for decision making;
- Provide a tool for policy monitoring, evaluation and revision;
- Allow for performance comparisons and identifying successful solutions;
- Identify interlinkages and trade-offs between dimensions, sectors, etc.
- Serve as communication tool to a wide range of stakeholders.

C) Project details

6 Methodology

Development of the ClEP indicator framework

The UN Sustainable Development Goals (SDGs) and the Paris Climate Agreement both imply ambitious (long-term) targets which only can be met with a fundamental restructuring of economic and social systems. In this context monitoring progress towards achievement of goals is essential and needs thorough measurement systems. The complexity of the issue calls for the use of indicator systems instead of single indicators.

The IEA and IAEA (2001) system of Sustainable Energy Development (SED) indicators and the ISED-AT framework (Kettner, Kletzan-Slamanig, and Köppl 2015b, 2015a) provide a broad range of indicators for all levels of the energy system. These indicator sets were the starting point for the development of the consistent energy service-based indicators in the ClEP project, i.e. together with a review of the broader relevant literature they were the basis for choosing relevant indicators in the demand-side sectors buildings, mobility, manufacturing and services as well as for energy supply that cover the three dimensions of sustainable development. These work steps finally resulted in a set of consistent indicators that was customised for Austria and other EU Member States. The conceptual development of indicators was closely connected to a first screening of relevant databases with respect to availability of appropriate data. Limited data availability (i.e. many indicators were only available for different countries and years which complicated both the selection of indicators and case study countries) required numerous iterations with WP3 and WP4 to compile the final set of indicators. The proposed indicators were validated with experts in a focus group discussion.

Development of the Composite Indices

In addition to the indicator set, a composite index for sustainable energy development was developed. The procedure for the calculation of this sustainable energy index followed Davidsdottir et al. 2007; Ibarrarán Viniegra, Davidsdottir, and Gracida Zurita 2009; Kettner, Kletzan-Slamanig, and Köppl 2015b, 2015a. The ClEP index either is structured by sector or by dimension of sustainable development; in the former case it is based on five sub-indices, one for each area (transport, residential buildings, manufacturing, services, electricity and heat supply); in the latter case it is based on three sub-indices, one for the ecological dimension, one for the economic dimension and one for the social dimensions. The sub-indices are calculated based on the following equation:

$$I_{i,t} = \sum_{j=1}^{n} w_j * \left(\frac{E_{i,j,t}}{E_{i,j,t=0}} - 1 \right)$$

where $I_{i,t}$ gives the sub-index of area i in year t, j is the energy indicator, n is the number of indicators, w_j is the weight for each indicator, and $E_{i,j,t}$ is the value of the energy indicator in year t. This means that each sub-index is the weighted sum of the change in the indicators compared to an assumed base year. The aggregate index is calculated as the weighted sum of the sub-indices. The indicators used to compute the index were normalised with the figures for Austria in 2010 to equal 100 in order to allow for a cross-country comparison.

Especially with respect to the social dimension, relevant data are rarely available for multiple countries or as time series. Therefore, we chose to provide an alternative composite index that requires fewer input data, i.e. it neglects the temporal dimension but performs a cross-country comparison based on the latest available data. While we could have also opted for a distance to reference country approach for calculating the extended sub-indices, we used the Min-Max methodology according to the following equation

$$I_{k,i} = \sum_{j=1}^{n} w_j * \left(\frac{E_{k,i,j} - E_{min,i,j}}{E_{max,i,j} - E_{min,i,j}} \right)$$

and the aggregate index is again calculated as the weighted sum of the sub-indices. This approach is frequently used for calculating composite indices in the context of the measurement of wellbeing and sustainable development, for instance for the Human Development Index or the OECD Better Life Index. The values of the extended composite index will hence range between 0 (if a country showed the worst performance with respect to all indicators included) and 1 (if a country showed the best performance with respect to all indicators included).

For the composite indices, we initially selected 30 indicators that are shown in black in Table 1. 14 indicators can be assigned to the ecologic dimension, 13 to the economic dimension and 3 to the social dimension. In terms of sectoral disaggregation, 10 indicators apply to the household sector, 7 to the transport sector, 4 each to the industry and service sector and 1 to electricity and heat supply.

As explained above, because of data limitations particularly for the social dimension an additional extended version of the index was calculated including also indicators that are only available for individual years (in total 42 indicators). These indicators are displayed in grey in Table 1. For the extended index, 13 indicators can be assigned to the residential sector, 12 to transport and 9 to electricity and heat supply; for industry and services again the same 4 indicators were used. When grouped by dimension of sustainable development, 15 indicators refer to the ecological dimension, 14 to the economic dimension and 13 to the social dimension.

The indicators for the composite index were selected to provide information on the different levels of the energy system as illustrated above and on all dimensions of sustainable energy development. Changes in the energy service proxies were not included in the index, since they cannot be interpreted in an unambiguous way (i.e. an improvement in energy efficiency, for instance, will always be beneficial for sustainability while this is not straightforward for an increase in the stock of appliances). Furthermore, the indicators should be characterised by good data availability and quality.

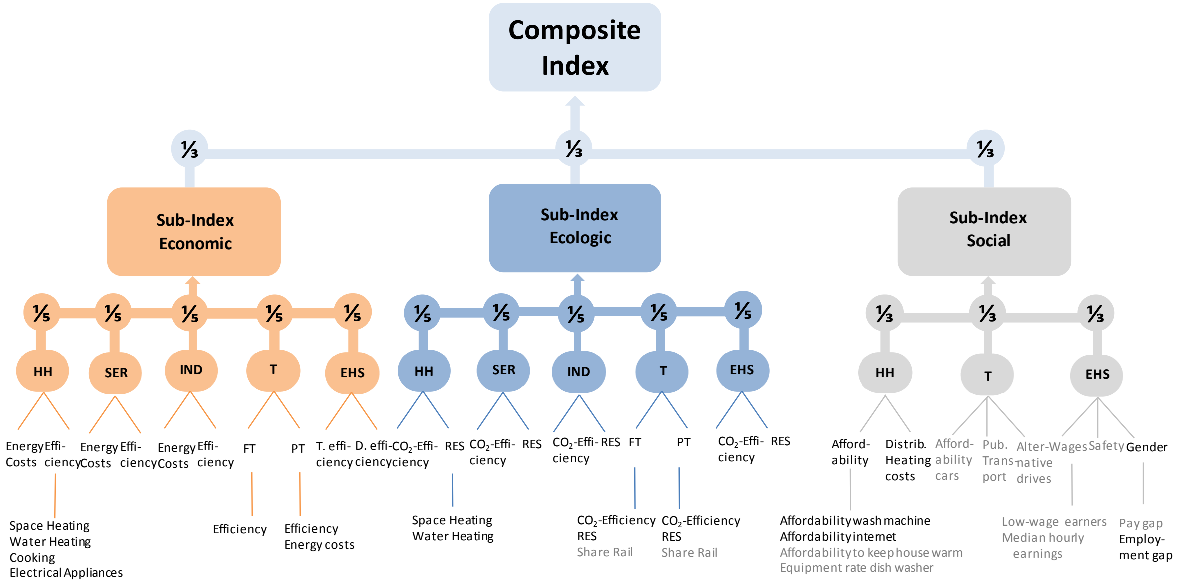
Table 3. List of indicators to be included in the composite indices

	Residential	Transport		Industry	Services	Electricity and Heat Supply
		Passenger T.	Freight T.			
Economic	Energy efficiency of space heating Energy efficiency of water heating Energy efficiency of cooking Energy efficiency of electrical appliances Energy cost share	Energy efficiency Energy cost share	Energy efficiency	Energy efficiency Energy cost share	Energy efficiency Energy cost share	Transformation efficiency Distribution efficiency
Environ-mental	Share of RES CO_2 Efficiency of space heating CO_2 Efficiency of water heating	Share of RES CO_2 Efficiency Share Rail in MS	Share of RES CO_2 Efficiency Share Rail in MS	Share of RES CO_2 Efficiency	Share of RES CO_2 Efficiency	Share of RES CO_2 Efficiency
Social	Affordability of washing machine Affordability to keep the house warm Affordability of internet connection Equipment rate of dishwashers Share of heating costs in HH income	Share of alternative drives in new registrations Accessibility of public transport Affordability of cars				Low wage earners Median hourly earnings Fatal incidents Gender pay gap Gender employment gap

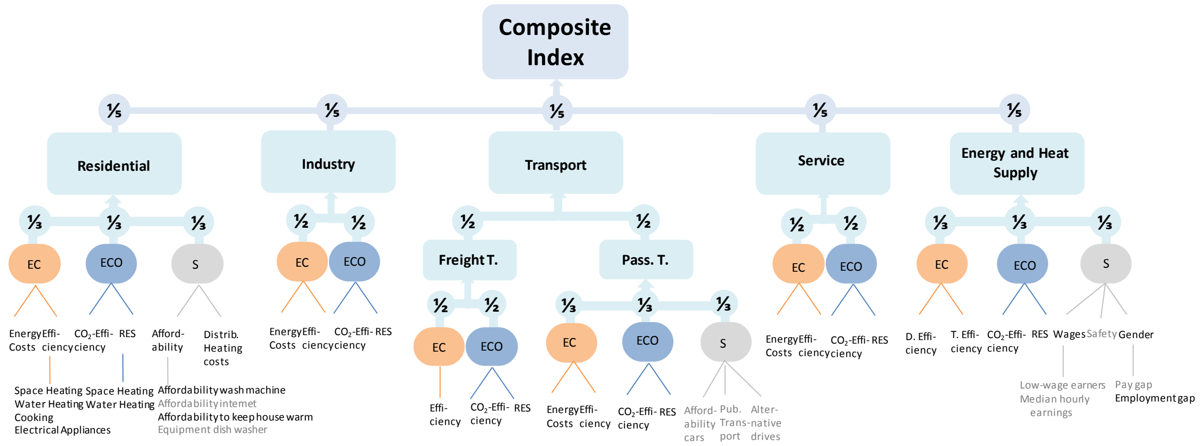
Figure 4 illustrates the way in which the indicators were aggregated for calculating the sectoral and dimensional sub-indices and finally the composite index. The different composition of the sub-indices thus determines the weight of the individual indicators in the calculation of the composite index and thus explains the disparity in the total values.

Figure 10. Aggregation structure of the composite indices

(a) Aggregation by sector and dimension



(b) Aggregation by dimension and sector



Discussion of interlinkages between dimensions and indicators

There are manifold interactions between the different SDGs and also between the different CIEP indicators. To assess interdependencies between indicators, we arranged them in a matrix (Annex 3 to this report) and applied the methodology developed by Nilsson et al. (2018). This approach classifies interactions on a scale from -3 to +3: -3 denotes cancelling targets while +3 denotes indivisible targets. The scores for the interactions were derived from intensive expert discussions. The research in CIEP confirmed that depending on the underlying assumptions, different development pathways are conceivable entailing different interactions between indicators and respectively dimensions.

Development of the database

In WP3 and WP4 a database on energy and carbon taxation in the EU Member States was set up. Data were collected from different sources and processed.

Diverse databases were used to collect the demand-side indicators (see Annex A2). Proxy data for energy services, i.e. the floor area of dwellings, passenger and freight transport performance as well as gross value added of the manufacturing and service sectors, and the related efficiency data are derived from the Odyssee database. The number of households, information on the different capital stocks and equipment rates as well as the sectoral shares of renewable energy sources are also taken from this database. Data on newly registered vehicles are obtained from the European Environment Agency's databases.

Data on energy flows, i.e. final energy demand, transformation input and transformation output by energy source, are taken from the IEA's Energy Balances. Plant capacity, energy prices and public energy R&D expenditures are also derived from IEA databases. Sectoral GHG emissions are taken from the UNFCCC's National Inventories.

Household income and expenditure originate from Eurostat, energy prices and sectoral public energy expenditure from the IEA. Complimentary information on sectoral patenting activities is taken from the OECD's EPO database.

Data on the social dimension are all taken from Eurostat, i.e. from the Structure of Earnings Survey, the Labour Force Survey and the European Statistics on accidents at work.

Development of policy recommendations

The development of policy recommendations in WP5 was based on the comprehensive analysis of indicators and composite indices compiled for the nine case study countries in the ClEP project. In addition, for a sub-set of countries (best performers plus the taillight country) an extensive literature review was carried out regarding the development of energy and climate policies as well as evaluation reports if available. Especially from the best performing countries similarities in policies have been identified that can be regarded as prerequisites for successful implementation of policies aiming at a sustainable transformation of the energy system while ensuring a minimisation of detrimental social impacts.

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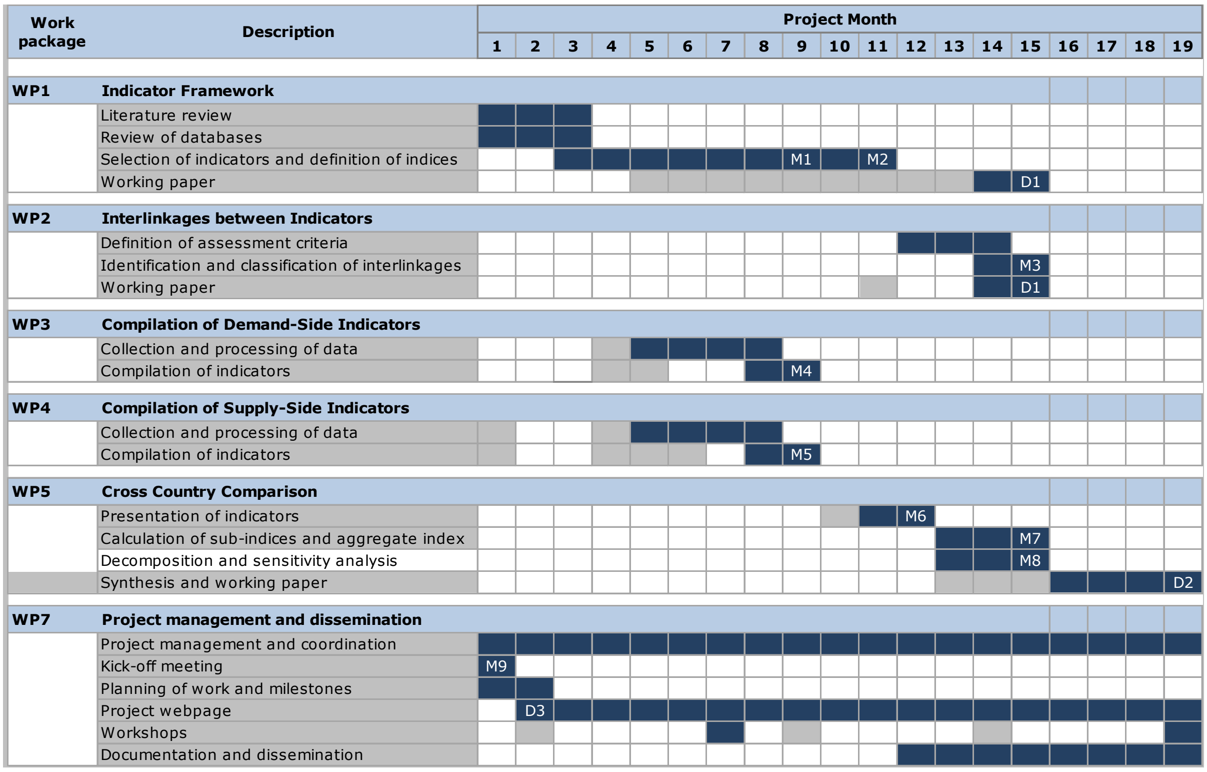
7 Work and time schedule



List of Milestones

M1	Indicator system
M2	Sub-indices and aggregate index
M3	Specification of interactions between indicators
M4	Indicators for the sectors mobility, buildings, manufacturing and services
M5	Indicators for energy supply
M6	Presentation of indicators
M7	Calculation of the sub-indices and the aggregate index for Austria
M8	Decomposition and sensitivity analyses
M9	Kick-off meeting

List of Deliverables

D1	Working paper on indicator system – joined output of WP1 and WP2
D2	Working paper on cross-country comparison
D3	Project web page

The project started on May 1st, 2017 and was planned for 15 months. The development of the indicator framework required many iterations between work packages 1, 3 and 4, and therefore the list of indicators could just be completed in spring 2018. We therefore applied for an extension of the project duration by four months until November 30th, 2018 to the program administration KPC. This was approved on April 16th, 2018.

In the final reporting period, one emphasis was put on WP2. We analysed comprehensively the interactions between the different indicators of the CIEP framework. This work was summarised in a joint working paper of WP1 and WP2 describing the conceptual approach for the indicator framework, the indicator set and synergies and trade-offs between different indicators. A focus of the second reporting period was the calculation of composite indices in WP5, as well as related sensitivity analyses. All work in the project was carried out as planned in the project proposal.

8 Publications and dissemination activities

Publications	
Working papers	
	Kettner C., D. Kletzan-Slamanig and A. Köppl, B. Littig and I. Zielinska (2018), Monitoring Sustainable Development. Climate and Energy Policy Indicators, WIFO Working Paper No. 573, https://www.wifo.ac.at/publikationen/working_papers?detail-view=yes&publikation_id=61557.
	Kettner C., D. Kletzan-Slamanig and A. Köppl, B. Littig and I. Zielinska (2019), Monitoring Sustainable Energy Development: A cross-country comparison of selected EU Members, WIFO Working Paper No. 575, https://www.wifo.ac.at/publikationen/working_papers?detail-view=yes&publikation_id=61593.
Conference proceedings	
	Littig, B., Zielinska, I. (2017), Soziale Indikatoren in der Energieforschung, in: Opielka, M., Renn, O. (eds.), Beiträge für das "Symposium: Soziale Nachhaltigkeit" am 2.11.2017, Potsdam (IASS).
Project workshops	
	ClEP expert focus group on November 27th, 2017
Project webpage	
	http://clep.wifo.ac.at/
Dissemination session at the 4th Growth in Transition Conference in Vienna	
Session "The SDGs as Compass for Transformation"	
	Transformations toward sustainable future disruptive technologies and lifestyles, Keynote by Nebojsa Nakicenovic (IIASA)
	Project Presentation Fritz Hinterberger (SERI - project meetPASS)
	Project Presentation Daniela Kletzan-Slamanig (WIFO - ClEP)
	Project Presentation Willi Haas (BOKU)
Presentations at international Conferences	
Symposium Soziale Nachhaltigkeit organised by the Institute for Advanced Sustainability Studies (IASS) in Potsdam	
	Littig, B. (2017), Energie- und Klimapolitische Nachhaltigkeitsindikatoren. Zur Konzeption sozialer Nachhaltigkeit im Kontext eines österreichischen Forschungsprojekts.
XXXI Congreso Asociación Latinoamericana de la Sociología (ALAS) de Montevideo 2017: Las encrucijadas abiertas de América Latina. La sociología en tiempos de cambios, Montevideo, December 3rd-8th, 2017	
	Littig, B. (2017), "Desarollo sustenible – trabajo – sexo".
Seminario Permanente: Procesos Laborales e Intelecto Colectivo, Foro Sur Sur de Ciencias Sociales: Encuentro - Taller: El debate sobre el trabajo sustentable, contextos, dinámicas y controver-	

sias. Análisis comparativo y perspectivas norte-sur on December 15th, 2017, in Buenos Aires	
	Littig, B. (2017), "Variantes discursivas sobre el trabajo sustentable".
Transformationen alltäglicher Lebensführung, which took place at the German Youth Institute (DJI) in Munich in March 2018:	
	Littig, B. (2018), Lebensführung revisited. Zur Aktualisierung eines Konzepts im Kontext der sozial-ökologischen Transformationsforschung.
Klimatag 2018 Salzburg	
	Kettner, C. (2018), ClEP Project presentation – Poster pitch session.

ANNEX A1

List of selected Indicators

Dimension [of sustainability]	Residential	Passenger Transport	Freight Transport	Manufacturing	Services	Electricity & Heat Supply
Drivers / Context	Floor area p.c. Housing stock No. of HH HH size HH income (by qu.) Energy prices Heating Degree Days	Stock of vehicles by category Share of e-vehicles Modal split Energy prices Road and rail km (Infrastructure indicator) Km of road / km of rail Specific CO_2 emissions of car stock Specific CO_2 emissions of newly registered cars	Stock of trucks Model split Energy prices Road and rail km (Infrastructure indicator) Km of road / km of rail	Share of GVA in GDP Energy prices Share of emission/energy intensive industry	Share of GVA in GDP Energy prices	Prices Carbon prices Capacity power plants
Energy Services (SDG Subgoal 7.1)	Well-tempered living space Illumination Warm water Cooking Communication / Entertainment Other	Mobility	Transport of goods	Proxy:GVA	Proxy:GVA	
Economic (SDG Subgoal 7.3)	Efficiency of residential sector Share of energy expenditure in household expenditure FEC* Public R&D expenditures energy Applied patents energy efficiency buildings	**Efficiency of passenger transport** **Share of transport expenditure in household expenditure** **FEC** Public R&D expenditures energy Public R&D expenditures for e-mobility Applied patents energy efficiency transport	**Efficiency of freight** **FEC**	**Efficiency of** **FEC** Public R&D expenditures energy efficiency industry Share of costs	Efficiency of service sector **FEC** Share of costs	Transformation efficiency Distribution efficiency Transformation input **Public energy R&D expenditures** **Applied energy technology patents**

Dimension [of sustainability]	Residential	Passenger Transport	Freight Transport	Manufacturing	Services	Electricity & Heat Supply
Ecological (SDG Subgoal 7.2)	% of RES in FEC CO_2 **emissions** NO_x **emissions** SO_2 **emissions** CO_2 **efficiency of FEC** NO_x **efficiency of FEC** SO_2 **efficiency of FEC**	% of RES in FEC CO_2 **emissions** NO_x **emissions** SO_2 **emissions** CO_2 **efficiency of FEC** NO_x **efficiency of FEC** SO_2 **efficiency of FEC**	% of RES in FEC CO_2 **emissions** NO_x **emissions** SO_2 **emissions** CO_2 **efficiency of FEC** NO_x **efficiency of FEC** SO_2 **efficiency of FEC**	% of RES in FEC CO_2 **emissions** NO_x **emissions** SO_2 **emissions** CO_2 **efficiency of FEC** NO_x **efficiency of FEC** SO_2 **efficiency of FEC**	% of RES in FEC CO_2 **emissions** NO_x **emissions** SO_2 **emissions** CO_2 **efficiency of FEC** NO_x **efficiency of FEC** SO_2 **efficiency of FEC**	% of RES in Electricity and Heat supply CO_2 **emissions** NO_x **emissions** SO_2 **emissions** CO2 efficiency of Electricity and Heat supply NOx efficiency of Electricity and Heat supply SO2 efficiency of Electricity and Heat supply
Social	Persons who cannot afford a telephone Persons who cannot afford a colour TV Persons who cannot afford a computer Persons who cannot afford a washing mashine Persons who cannot afford internet connection for personal use at home Population unable to keep home adequately warm by poverty status Share of Heating costs in HH income by quintile Equipment rate - fridge Equipment rate - freezer Equipment rate - washing machine Equipment rate - dishwasher Equipment rate - TV	New registrations of passenger cars New registrations of electric passenger cars New registrations of passenger cars alternative energy Mobility infrastructure_Public transport Persons who cannot afford a car				**Working conditions _** **Income & benefits from employment** Low-wage earners Median hourly earnings **Working conditions_Temporary work** Temporary contracts **Working conditions_Health and safety at work** Incidence rate of fatal accidents at work **Working conditions_Work-life balance** Flexibility of the work schedule **Equal opportunities** Gender pay gap Gender employment rate gap

ANNEX A2

List of data sources

Data Sources - Supply Side

Dimension	Indicator	Source
Drivers	Energy Prices	IEA Energy Price Taxes
	Carbon prices	EEX
	Capacity power plants	IEA Electricity information
Economic	Transformation efficiency electricity plants	IEA Energy Balances
	Transformation efficiency CHP	IEA Energy Balances
	Transformation efficiency heat plants	IEA Energy Balances
	Distribution efficiency electricity	IEA Energy Balances
	Distribution efficiency heat	IEA Energy Balances
	Transformation input	IEA Energy Balances
	Public energy R&D expenditures	IEA, Energy R&D Expenditures
	Applied energy technology patents	OECD; EPO database
Ecological	% of RES in Electricity and Heat supply	IEA Energy Balances
	CO2 emissions	UNFCCC, National Inventory Reports
	NOx emissions	UNFCCC, National Inventory Reports
	SO2 emissions	UNFCCC, National Inventory Reports
	CO2 efficiency of Electricity and Heat supply	UNFCCC, National Inventory Reports
	NOx efficiency of Electricity and Heat supply	UNFCCC, National Inventory Reports
	SO2 efficiency of Electricity and Heat supply	UNFCCC, National Inventory Reports
Social	Low-wage earners	Eurostat, Strucutre of Earning Survey
	Median hourly earnings	Eurostat, Strucutre of Earning Survey
	Collective pay agreement	Eurostat, Strucutre of Earning Survey
	Temporary contracts	Eurostat, Strucutre of Earning Survey
	Incidence rate of fatal accidents at work	Eurostat - European Statistics on accidents at work (ESAW)

Data Sources - Demand Side

Dimension	Sector	Indicator	Source
Drivers	Residential	Household data	Odyssee database
	Transport	Car stock data	Odyssee database
	Transport	Modal split	Odyssee database
	Transport	Road/rail km	Odyssee database
	Residential	HH income (qu.)	EU-SILC
	All sectors	Energy prices	IEA Energy Price Taxes
	Transport	Share of e-vehicles	EEA, CO2 emissions from passenger cars
	Transport	Share of alternative drives	EEA, CO2 emissions from passenger cars
	Transport	Specific CO2 emissions of newly registered cars	EEA, CO2 emissions from passenger cars
	Transport	Specific CO2 emissions of car stock	Odyssee database
	Industry/Service	GVA	Odyssee database
Energy Service	All sectors	Energy service data	Odyssee database
Economic	All sectors	Energy efficiency data	Odyssee database
	All sectors	R&D data	IEA, Energy R&D Expenditures
	All sectors	Patent data	OECD, EPO database
	Residential/Transport	Share of energy expenditure	Eurostat, COICOP
	Industry/Service	Share of energy costs	IEA, Odyssee
Ecologic	All sectors	Share of renewables in sectors	Odyssee database
	All sectors	Emission data	UNFCCC, National Inventory Reports
Social	Residential/Transport	Affordability data	Eurostat, EU-Silc
	Residential	Equipment rates	Odyssee database
	Residential	Share of heating costs (qu.)	Eurostat, Household budget survey
	Transport	New registration of cars	EEA, CO2 emissions from passenger cars
	Transport	Accessibility of public transport	Eurostat, EU-Silc

Flexibility of the work schedule	Eurostat: Labour Force Survey (LFS)
Gender pay gap	Eurostat: Labour Force Survey (LFS)
Gender employment gap	Eurostat - Structure of Earnings Survey (SES)

ANNEX A3

Interdependencies of indicators

	Economic									
	Efficiency	Increased share of housing energy expenditure	Decreased final energy consumption	Public R&D expenditures	Applied patents	Increased share of transport expenditure	Increased share of energy costs in industry and service sector	Transformation efficiency	Distribution efficiency	Reduced transformation input
Floor area p.c.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Housing stock	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
No. of HH	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
HH size	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Inequality of household income	n.a.	1	n.a.	n.a.	n.a.	1	n.a.	n.a.	n.a.	n.a.
Fossil energy prices	1	-2	2	n.a.	n.a.	-2	-2	2	2	2
Heating Degree Days	n.a.	-1	-1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Car stock	n.a.	n.a.	-2	n.a.	n.a.	-2	n.a.	n.a.	n.a.	n.a.
Share of e-vehicles	1	n.a.	1	n.a.	n.a.	-1 / 1	n.a.	n.a.	n.a.	-1
Share of public transport	2	n.a.	2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Km of road / km of rail	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Specific CO_2 emissions efficiency of car stock	3	n.a.	2	n.a.	n.a.	-1 / 1	n.a.	n.a.	n.a.	n.a.
Specific CO_2 emissions efficiency of car stock with increasing diesel share	3	n.a.	2	n.a.	n.a.	-1 / 1	n.a.	n.a.	n.a.	n.a.
Specific CO_2 emissions efficiency of newly registered cars	3	n.a.	2	n.a.	n.a.	-1 / 1	n.a.	n.a.	n.a.	n.a.
Specific CO_2 emissions efficiency of newly registered cars with increasing diesel	3	n.a.	2	n.a.	n.a.	-1 / 1	n.a.	n.a.	n.a.	n.a.
Stock of trucks	n.a.	n.a.	-2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Share of emission/energy intensive industry	-1	n.a.	-1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Share of GVA in GDP	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
ETS Carbon prices	2	-1	2	n.a.	n.a.	-1	-1	2	2	n.a.
Capacity power plants	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Efficiency	\	1	3	n.a.	n.a.	1	1	n.a.	n.a.	n.a.
Share of housing energy expenditure in household expenditure	1	\	1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
FEC*	-3	-1	\	n.a.	n.a.	-1	-1	n.a.	n.a.	n.a.
Public R&D expenditures	1	n.a.	1	\	n.a.	n.a.	n.a.	1	1	1
Applied patents	1	n.a.	1	n.a.	\	n.a.	n.a.	1	1	1
Share of transport expenditure in household expenditure	1	n.a.	1	n.a.	n.a.	\	n.a.	n.a.	n.a.	n.a.
Share of energy costs for industry and service sector	2	n.a.	2	n.a.	n.a.	n.a.	\	n.a.	n.a.	n.a.
Transformation efficiency	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	\	n.a.	n.a.
Distribution efficiency	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	\	n.a.
Transformation input	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	\
% of RES in FEC	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2	n.a.	n.a.
CO_2 emissions	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
NO_x emissions	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
SO_2 emissions	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
CO_2 efficiency of FEC	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
NO_x efficiency of FEC	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
SO_2 efficiency of FEC	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Affordability of TV, PC, WM, Internet	n.a.	-1	-1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Population able to keep home adequately warm	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Inequality of share of Heating costs by quintile	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Equipment rate - fridge, freezer, WM, DW, TV	n.a.	-1	-1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
New registrations of EL, AIT passenger cars	1	n.a.	1	n.a.	n.a.	-1 / 1	n.a.	n.a.	n.a.	n.a.
Access to public transport	1	n.a.	1	n.a.	n.a.	1	n.a.	n.a.	n.a.	n.a.
Afffordability of cars	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Low-wage earners	n.a.	-1	1	n.a.	n.a.	-1	n.a.	n.a.	n.a.	n.a.
Median hourly earnings	n.a.	1	-1	n.a.	n.a.	1	n.a.	n.a.	n.a.	n.a.
Temporary contracts	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Incidence rate of fatal accidents at work	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Flexibility of the work schedule	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Gender pay gap	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Gender employment gap	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

	Ecological						
	% of RES in FEC	Reduced CO2 emissions	Reduced NOx emissions	Reduced SO2 emissions	CO2 efficiency of FEC	NOx efficiency of FEC	SO2 efficiency of FEC
Floor area p.c.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Housing stock	n.a.	-1	-1	-1	n.a.	n.a.	n.a.
No. of HH	n.a.	-1	-1	-1	n.a.	n.a.	n.a.
HH size	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Inequality of household income	n.a.	-1	-1	-1	n.a.	n.a.	n.a.
Fossil energy prices	2	2	2	2	2	2	2
Heating Degree Days	n.a.	-1	-1	-1	-1	-1	-1
Car stock	n.a.	-2	-2	-2	n.a.	n.a.	n.a.
Share of e-vehicles	n.a.	1	1	1	3	3	3
Share of public transport	n.a.	2	2	2	2	2	2
Km of road / km of rail	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Specific CO_2 emissions efficiency of car stock	n.a.	1	1	1	n.a.	n.a.	n.a.
Specific CO_2 emissions efficiency of car stock with increasing diesel share	n.a.	1	-1	1	n.a.	n.a.	n.a.
Specific CO_2 emissions efficiency of newly registered cars	n.a.	1	1	1	n.a.	n.a.	n.a.
Specific CO_2 emissions efficiency of newly registered cars with increasing diesel share	n.a.	1	-1	1	n.a.	n.a.	n.a.
Stock of trucks	n.a.	-2	-2	-2	n.a.	n.a.	n.a.
Share of emission/energy intensive industry	-1	-2	-2	-2	-2	-2	-2
Share of GVA in GDP	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
ETS Carbon prices	2	2	2	2	2	2	2
Capacity power plants	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Efficiency	n.a.	2	2	2	n.a.	n.a.	n.a.
Share of housing energy expenditure in household expenditure	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
FEC*	n.a.	-2	-2	-2	n.a.	n.a.	n.a.
Public R&D expenditures	1	1	1	1	1	1	1
Applied patents	1	1	1	1	1	1	1
Share of transport expenditure in household expenditure	n.a.	1	1	1	n.a..	n.a..	n.a..
Share of energy costs for industry and service sector	n.a.	1	1	1	n.a.	n.a.	n.a.
Transformation efficiency	n.a.	2	2	2	n.a.	n.a.	n.a.
Distribution efficiency	n.a.	2	2	2	n.a.	n.a.	n.a.
Transformation input	n.a.	-2	-2	-2	n.a.	n.a.	n.a.
% of RES in FEC	\	3	3	3	3	3	3
CO_2 emissions	n.a.	\	n.a.	n.a.	n.a.	n.a.	n.a.
NO_x emissions	n.a.	n.a.	\	n.a.	n.a.	n.a.	n.a.
SO_2 emissions	n.a.	n.a.	n.a.	\	n.a.	n.a.	n.a.
CO_2 efficiency of FEC	n.a.	n.a.	n.a.	n.a.	\	n.a.	n.a.
NO_x efficiency of FEC	n.a.	n.a.	n.a.	n.a.	n.a.	\	n.a.
SO_2 efficiency of FEC	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	\
Affordability of TV, PC, WM, Internet	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Population able to keep home adequately warm	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Inequality of share of Heating costs by quintile	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Equipment rate - fridge, freezer, WM, DW, TV	n.a.	-1	-1	-1	n.a.	n.a.	n.a.
New registrations of EL, AIT passenger cars	n.a.	2	2	2	2	2	2
Access to public transport	n.a.	1	1	1	n.a.	n.a.	n.a.
Afffordability of cars	n.a.	-1	-1	-1	n.a.	n.a.	n.a.
Low-wage earners	n.a.	1	1	1	n.a.	n.a.	n.a.
Median hourly earnings	n.a.	-1	-1	-1	n.a.	n.a.	n.a.
Temporary contracts	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Incidence rate of fatal accidents at work	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Flexibility of the work schedule	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Gender pay gap	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Gender employment gap	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

	Social						
	Affordability of TV, PC, WM, Internet	Population able to keep home adequately warm	Reducing inequality of share of Heating costs	Equipment rate - fridge, freezer, WM, DW, TV	New registrations of EL, AIT passenger cars	Access to public transport	Affordability of cars
Floor area p.c.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Housing stock	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
No. of HH	n.a.	n.a.	n.a.	n.a.	n.a.	1	n.a.
HH size	n.a.	n.a.	n.a.	1	n.a.	n.a.	n.a.
Inequality of household income	2	2	2	1	n.a.	n.a.	2
Fossil energy prices	-2	-2	-2	-2	1	n.a.	-2
Heating Degree Days	n.a..	-1	-2	n.a..	n.a..	n.a..	n.a..
Car stock	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Share of e-vehicles	n.a.	n.a.	n.a.	n.a.	3	n.a.	n.a.
Share of public transport	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Km of road / km of rail	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Specific CO_2 emissions efficiency of car stock	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Specific CO_2 emissions efficiency of car stock with increasing diesel share	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Specific CO_2 emissions efficiency of newly registered cars	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Specific CO_2 emissions efficiency of newly registered cars with increasing diesel share	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Stock of trucks	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Share of emission/energy intensive industry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Share of GVA in GDP	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
ETS Carbon prices	-2	-2	-2	-2	1	n.a.	-2
Capacity power plants	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Efficiency	n.a..	2	2	n.a.	n.a.	n.a.	n.a.
Share of housing energy expenditure in household expenditure	-2	-2	n.a.	-2	n.a.	n.a.	n.a.
FEC*	n.a..	-2	-2	n.a.	n.a.	n.a.	n.a.
Public R&D expenditures	n.a..	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Applied patents	n.a..	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Share of transport expenditure in household expenditure	n.a..	n.a.	n.a.	n.a.	n.a.	n.a.	-2
Share of energy costs for industry and service sector	n.a..	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Transformation efficiency	n.a..	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Distribution efficiency	n.a..	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Transformation input	n.a..	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
% of RES in FEC	n.a..	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
CO_2 emissions	n.a..	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
NO_x emissions	n.a..	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
SO_2 emissions	n.a..	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
CO_2 efficiency of FEC	n.a..	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
NO_x efficiency of FEC	n.a..	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
SO_2 efficiency of FEC	n.a..	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Affordability of TV, PC, WM, Internet	/	n.a.	n.a.	1	n.a.	n.a.	n.a.
Population able to keep home adequately warm	n.a..	/	2	1	1	n.a.	1
Inequality of share of Heating costs by quintile	n.a..	2	/	1	n.a.	n.a.	1
Equipment rate - fridge, freezer, WM, DW, TV	1	n.a.	1	/	n.a.	n.a.	n.a.
New registrations of EL, AIT passenger cars	n.a..	n.a.	n.a.	n.a.	/	n.a.	n.a.
Access to public transport	n.a..	n.a.	n.a.	n.a.	-1	/	n.a.
Afffordability of cars	n.a..	n.a.	n.a.	n.a.	3	n.a.	/
Low-wage earners	-1	-2	-2	-1	-1	n.a.	-1
Median hourly earnings	1	2	2	2	1	n.a.	1
Temporary contracts	-1	-1	-1	-1	-1	n.a.	-1
Incidence rate of fatal accidents at work	n.a..	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Flexibility of the work schedule	n.a..	n.a.	n.a.	n.a.	n.a.	1	n.a.
Gender pay gap	1	1	1	1	1	n.a.	1
Gender employment gap	1	1	1	1	1	n.a.	1