Energy Policy 152 (2021) 112216

Contents lists available at ScienceDirect

Energy Policy

journal homepage: http://www.elsevier.com/locate/enpol

Energy Efficiency Vision 2050: How will new societal trends influence future energy demand in the European countries?

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ARTICLE INFO

Keywords:
Energy policy
New societal trends
European targets 2050
Energy efficiency
Energy demand
Energy scenarios

ABSTRACT

New societal trends are unfolding, such as digitalization, sharing economy and consumer awareness. They will highly influence future energy demand and, depending on their realization, enhance or counteract projected energy efficiency gains. Therefore, these trends have to be accompanied by policies with a strong focus on reducing energy demand (including Energy Efficiency First). This work analyzes quantitatively for all sectors how New Societal Trends interact with energy efficiency (policies).

An extensive consultation with European experts identified 12 new societal trends that are likely to shape future energy demand. Based on these, four energy demand scenarios were developed for 2050. Using literature review and expert consultations, the impacts on all sectors were evaluated taking these trends explicitly into account. The results show that New Societal Trends can have a crucial impact on future energy demand beyond mere techno-economic potentials. In the best case scenario, "New Trends Efficient", they can reduce final energy demand by 67% compared to the EU "Baseline" scenario in 2050. While in the "Worst Case" scenario, they could increase final energy demand by 40%.

This paper opens up the discussion on how New Societal Trends will shape future energy demand and emphasizes the crucial role of policy-making therein.

1. Introduction

The central aim of the 2015 Paris Agreement is to strengthen the global response to the threat of climate change by keeping the global temperature rise within this century well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 °C (United Nations, 2015). To reach this ambitious goal, two central strategies are pursued by the European Union (EU) and its Member States concerning the energy system: (1) enhancing energy efficiency (EE) and (2) decarbonizing energy supply, in particular via large diffusion and wide-use of renewable energy sources. While both strategies are necessary for maintaining the chance to reach the targets, they might not be sufficient. The past has shown that in many areas energy efficiency gains were counteracted by societal trends that increased corresponding activities, leading to much smaller decreases (or even increases) of energy demand than technologically feasible. Examples of this process are found in all sectors, such as the utilization of larger vehicles in private transport (IEA, 2019), increasing internet traffic and energy demand from servers, data centers and information technology infrastructure (Masanet et al., 2020) or the increase in the living area per person (Odyssee-Mure, 2018).[1] Therefore, it is important to access current and (foreseeable) future societal trends concerning the impact that they might have on future energy demand. By "new societal trends" in this paper we understand trends which – though they may have been around for quite some time in the form of "niche trends" – may suddenly gain considerable momentum due to new technologies supporting them and/or new views of larger parts of society on the values behind those trends. It lies in the nature of these new societal

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[1] The concept of energy sufficiency gains increasing importance in this context. Energy sufficiency is defines as "a state in which people's basic needs for energy services are met equitably and ecological limits are respected." (eceee, 2018). It places the needs of the people at the center and focusses on how these needs can be met (e.g. need for a comfortable home or need for mobility), rather than solely focusing on technological enhancements of the energy services. Energy sufficiency therefore plays a crucial role in mitigating direct and indirect rebound effects of energy efficiency gains.

https://doi.org/10.1016/j.enpol.2021.112216
Received 22 July 2020; Received in revised form 24 January 2021; Accepted 14 February 2021
Available online 3 March 2021

trends that assessing their impact is linked to high degrees of uncertainty. This makes increasing awareness towards their potential impact – which may not simply be linear extrapolations of past trends – even more crucial, since in many areas policies and (consumer) awareness might play a major role in shaping how these impacts will actually unfold.

The arising new societal trends can often be linked to general megatrends, which in turn can have potentially large increasing or decreasing impacts on energy demand (Wadud et al., 2016). Within this work these arising trends were clustered into the four following trend clusters (for the detailed process, see section 3): (1) the *digitalization* of the economy and of private life; (2) *new social and economic models*, including the *sharing economy* and *prosumaging* (combination of producing, consuming and managing of energy); (3) the *industrial transformation*, including *decarbonization of industrial processes* and the *circular economy* (including a stronger focus on material efficiency); and (4) *changes in the quality of life*, including *health effects*, *urbanization* and *regionalization*. The trend towards digitalization may also act as a facilitator for all other trends. The diffusion of cell phone apps for example facilitates car sharing. Table 1 presents an overview of the four trend clusters and their corresponding trends.

The European Commission emphasizes the role of new societal (mega) trends in their "A Clean Planet for all" communication (2016b) and particular in their corresponding long-term strategic vision (European Commission, 2018b). Therefore, it is not surprising that many studies analyze the effect of these new societal trends on future energy demand. Yet, most existing studies concentrate on a single or very few trends or only cover specific sectors (see literature overview below, one valuable and recent exemption is provided by Grubler et al., 2018). However, new societal trends have (1) the potential to shift energy demands between sectors[2] and (2) might reinforce or diminish one another when they occur at the same time. Therefore, the here provided approach - starting from a systematic foresight analysis of new societal trends and investigating the potential impact of such trends on future energy demand in a systemic manner - provides an important addition to the recent emerging literature in this area. The main research question is:

Table 1
The four societal trend clusters and the detailed trends they encompass.

Cluster	Trend
Digitalization of Life	Human-Machine/Shift towards smart products and services
New Social and Economic Models	Sharing economy
	Prosumer
	Awareness (of personal carbon footprint)
	Social disparities/Energy poverty
	New forms of funding – Public spending towards greener and more efficient options
Industrial Transformation	Reindustrialization
	Circular Economy – New requirements for material flows for consumer goods
	Decarbonization of the industry
Quality of Life	Increasing importance of health (e.g. air quality, noise, heat)
	Regionalization – Urban governance solving global challenges locally in cities
	Urbanization – Global trend towards larger shares of the population living in cities

[2] For example increasing online sales leads to a shift of energy demand away from the tertiary sector towards the transport sector or the trend toward more home office inducing a higher energy demand in private households while at the same time decreasing energy demand in the transport sector.

1.1. *How may new societal trends influence energy demand in different sectors in the European Union until 2050?*

Following the introduction, section 2 will present an overview of the knowledge in present literature on the four new societal trend clusters introduced in section 1. In section 3 a systematic methodological approach will be followed to establish these four clusters by identifying and clustering new societal trends that are likely to shape future energy demand in European countries (and worldwide). In addition, a modelling approach to identify how the new societal trends can be represented in an energy system model and with which key parameters will be described. Section 4 will present the analysis of the new societal trends in the different scenarios and provides a first quantitative estimate of how they might interact with energy efficiency gains as well as the development of energy demand in different sectors. Section 5 will discuss limitations of the proposed approach. Finally, section 6 will formulate an answer to the main research question and draw a conclusion.

2. Theoretical background

Section 2 presents the analysis of the literature findings for the four clusters of new societal trends introduced in section 1: 1) *digitalization*, (2) *new social and economic models,* (3) *industrial transformation*, and (4) *changes in the quality of life.*

The impact of new societal trends on energy demand is gaining attention in the academic literature (see for example Grubler et al., 2018; Wadud et al., 2016; Pfaffenrot, 2017; Hamari et al., 2016; Urbach and Röglinger, 2019; Walter and Sillanpää, 2018; Debref, 2018) as well as in applied projects and reports (see for example "Pathways for Carbon Transition" from the European Commission (2010a; 2010b; 2010c; 2011); "Digitalization and energy" from IEA/OECD (2017); "Study on national policies reported in the transport sector for 2021–2030" by Ricardo (2017)).

The proposed approaches have different aims, among which are the following: to analyze long-term scenarios until 2050 and the paths of renewable energy development (for example in the 95% scenario of Öko-Institut et al., 2016); to describe a specific trend itself, the technologies it implies and the impact of this trend on the development of different sectors and the low-carbon society as a whole (BAMB, 2016; European Commission, 2010a; European Commission, 2010b; EU Calc, 2017; IEA/OECD, 2017; Material Economics, 2018; UKERC, 2011); to identify and quantify how a specific trend may drive the competitiveness of the EU in the specific industry, including cost and productivity gains (European Commission, 2017); to understand the specific policies needed to achieve energy savings in different sectors and the potential contribution that national policy measures could make in the future (Ricardo, 2017); to describe how trends might unfold beneficially to reach a 1.5° scenario (Grubler et al., 2018); to outline what a sustainable post-carbon society would look like in the next 50 years (European Commission, 2010c) and to analyze the consumer engagement in the development of a specific trend (European Commission, 2018a). Different qualitative and quantitative methods have been used in recent studies separately or in combination. Qualitative methods include literature review (IEA/OECD, 2017), expert and stakeholder workshops and interviews (EU Calc, 2017), surveys and behavioral experiments (European Commission, 2018a), scenario development (European Commission, 2010a, 2010b; Ricardo, 2017). Quantitative methods, commonly applied to access the impact of new societal trends, amongst others are the analysis of statistical data (UKERC, 2011; Wadud et al., 2016), linguistic (semantic) analysis (European Commission, 2010c), energy modelling (UKERC, 2011), integrated assessment models (Grubler et al., 2018), cost-benefit analysis and economic modelling (European Commission, 2017; Material Economics, 2018).

In Table 2 a number of studies analyzing strong climate reduction scenarios from a techno-economic perspective are introduced, which

Table 2
Examples of studies related to the influence of new societal trends on energy consumption.

Trend cluster	Author (year)	Location	Time frame	Methodology	Main findings
Digitalization of Life	IEA/OECD (2017)	International	2040–2050	Qualitative (scenario development, expert consultations). Quantitative (economic modelling).	The authors summarize how digitalization may increase efficiency, productivity and energy savings in three sectors (transport, buildings and industry), qualitatively assessing the magnitude of potential impacts and associated barriers. They conclude that digital technologies and applications face a variety of barriers to adoption and use and that their impacts on energy demand differ substantially across demand sectors and within different scenarios.
	European Commission (2017)	EU	2030 and beyond	Qualitative (scenario development, expert consultations). Quantitative (economic modelling).	The analysis reveals important findings on the opportunities and costs that the automotive industry will likely face in the context of rapid technological changes and an uncertain global regulatory environment. Based on these findings and associated conclusions, recommendations are proposed on how the EC can support the automotive industry in the EU in this period of change, focusing on M1/N1-category vehicles, L-category vehicles and the automotive supply chain.
	BAMB (2016)	EU	2020–2030	Qualitative (desk research, expertise from BAMB consortium). Quantitative (statistical analysis).	Twelve main opportunities (grouped into: policy opportunities, R&D opportunities, business opportunities and creation of building qualities for users and owners) and ten key barriers (grouped into: policy barriers, commercial barriers and communicative barriers) have been identified when Materials Passports and Reversible Building Design Protocols – as part of the integrated BAMB output – should be fully implemented.
New Social and Economic Models	European Commission (2018a)	EU	2020–2030	Qualitative (literature review, stakeholder interviews (semi-structured), consumer focus groups and online survey, behavioral experiment). Quantitative (data mining, statistical analysis).	The European Commission (2018a) aims to analyze consumers' engagement in the circular economy focusing on five main products: smartphones, televisions, vacuum cleaners, dishwashers and clothing. They investigate consumer willingness to engage in the circular economy; consumer expectations and experiences with durability and reparability; the drivers, barriers and trade-offs faced by consumers and the effects of product information on purchasing decisions.
	EU Calc (2017)	EU	2050	Qualitative (the EU calculator expert workshop on lifestyles and lifestyle changes in Europe).	The report analyses how the sustainable lifestyle changes (consumption choices and patterns) may influence the energy consumption in three sectors: buildings, transportation and food/diets. It is concluded that the energy system (energy supply and demand) covers everything from basic needs to economic desires and therefore, behavioral aspects, as well as structural, institutional and political conditions should be taken into account.
	UKERC (2011)	UK	2050	Qualitative (scenario development, expert consultations), quantitative (statistical analysis).	The authors study consumer awareness through analyzing the role of pro-environmental lifestyle changes for the UK energy system up to 2050. The results indicate that energy use might be expected to fall in both the household and transport sectors by approximately 50% in each by 2050, which implies energy demand decreases of just below 2% annually.
Industrial Transformation	Material Economics (2018)	EU	2050	Quantitative (statistical analysis, economic modelling).	The study shows how a more circular economy can contribute to cutting GHG emissions from heavy industry. Three circular economy strategies that make better use of materials and products to reduce GHG emissions in 2050 are discussed in the report. The findings suggest that a more circular economy can produce deep cuts to emissions from heavy industry. Demand-side measures thus can take us more than halfway to net-zero emissions from the EU industry and hold as much promise as those on the supply side.
	Öko-Institut e.V. / Fraunhofer ISI / IREES GmbH (2016)	Germany	2050	Qualitative (scenario development). Quantitative (statistical analysis, economic modelling).	The following three conclusions can be drawn from the scenarios: 1. From a technical and economic perspective, the ambitious targets of Germany's Energy Concept are achievable. 2. The minimum target path set out in Germany's Energy Concept is just about sufficient for 2020 to 2040 to achieve a reduction of 80% by 2050. 3. With a 95% reduction target, substantially more ambitious emission

(*continued on next page*)

Table 2 (*continued*)

Trend cluster	Author (year)	Location	Time frame	Methodology	Main findings
					reductions have to be realized by all sectors than would be the case with an 80% target.
	Wadud et al. (2016)	USA	2050	Qualitative (expert consultations). Quantitative (statistical analysis).	Wadud et al. (2016) identify and quantify specific mechanisms through which automation may affect travel and energy demand and resulting GHG emissions. They assess the impacts of these mechanisms through a coherent energy decomposition framework. They conclude that automation might plausibly either reduce road transport GHG emissions and energy use by nearly half – or nearly double them.
Quality of Life	European Commission (2010a)	EU	2050	Qualitative (scenario development). Quantitative (statistical analysis, spatial data analysis).	Focusing on the trend of urbanization, the European Commission (2010a) studies the relationship between urbanized forms of living and energy needs respectively possibilities of energy supply – to envision future long-term energy scenarios for different imaginable settlements in Europe.
	European Commission (2010b)	EU	2050	Qualitative (scenario development). Quantitative (statistical analysis, modelling).	The European Commission (2010b) provides a qualitative overview of the technologies and lifestyles that would make up a low-carbon society in Europe in 2050. This research includes an initial assessment of the material intensity of current technologies in the areas of housing, transport and energy service, and links these technologies to the different urban schemes and land use clusters.
	European Commission (2010c)	EU	2050	Qualitative (literature review, expert interviews, web-based survey). Quantitative (semantic analysis, statistical analysis, modelling).	The most important findings of the report, both as regards the production of new knowledge on energy transition and the elaboration of scenarios for future development, are presented in a model called Sociological Predictive Operational Model on Energy Transition (SPROMET), which pursues an operational objective, namely to provide a sociological interpretation of energy transition that could form the basis for developing predictive analyses.

contain more or fewer elements linked to the new societal trends mentioned above.

This brief literature overview of the new societal trends shows that all the trend clusters have the potential to decrease energy demand, but they might also drastically increase energy demand (some more than others) if trends unfold in unbeneficial circumstances (e.g. without guiding policies that put decreasing energy demand at the center or without consumer awareness). While a wide range of studies on new societal trends exists, the literature review unveiled that several aspects in the analysis of the effect of new societal trends on energy demand have proven to be understudied. For many of the trends that are expected to have major impacts on future energy demand no previous studies exist, not even ones which determine the qualitative effects of a trend on the energy demand. More specifically, a quantification of the effects of these trends on energy demand exists only for selected trends (such as digitalization – IEA/OECD, 2017) and even in these cases only for selected subparts. Challenges that have been identified in the previous studies are: that these studies are often not transparent in their baseline assumptions, that parameters have to be meaningfully adapted to the EU context and that model parameters – in case of a model-based quantitative analysis of this trends – need to account for double-counting of certain mechanisms.

3. Methodology

This section presents the methodology used to derive and quantify new societal trends. For this purpose, three expert workshops were carried out in the period between January and September 2018, with 20–30 European energy experts each, to explore the 2050 energy perspective, supported by analytical work. Experts came from across the EU with different professional backgrounds, ranging from representatives of industrial sectors to representatives of environmentalist organizations.

This study was performed in four consecutive methodological steps: (1) trend identification, (2) deep dive analysis, (3) expert discussion and (4) scenario development and model-based analysis. These steps are described in turn and the process is visualized in Fig. 1. Afterwards, the developed scenarios are described.

Steps 1 to 3 focused on the identification of the societal trends that are expected to have a major impact on the realization of energy efficiency potentials and might substantially increase or decrease energy demand. Step 4 focused on the analysis of the impact of these societal trends on the modelling parameters within the different scenarios developed.

Step 1: Trend identification. The trend identification was developed on the basis of a study executed by VDI-Technologiezentrum/-Fraunhofer ISI (2017), in which a set of megatrends and detailed trend profiles was developed. The societal trends were selected based on (1) their *social relevance,* where the importance of a trend is determined by significant social and/or economic and in some cases also disruptive impacts; (2) their *time dimension,* when impacts of the trend are relevant in a period of time extending from now until 2030 (all of the identified trends have proven to be relevant beyond the year 2030, however, additional societal trends are likely to become important in the interval leading up to 2050, which cannot be foreseen at the current point in time); (3) their *relationship to research and innovation (R&I)*, where the trend as a whole or in some aspects should clearly relate to research and innovation; and (4) the *degree of "novelty" of a social trend*, whether the social trend is wholly or partly new for the research and innovation system, or, in the opinion of the authors and experts involved, has received too little attention to date (VDI-Technologiezentrum/Fraunhofer ISI, 2017). Through this process, 60 societal trends and 24 megatrends were identified. The trend profiles were developed in the context of major changes, so-called megatrends, such as increased urbanization, increased number of

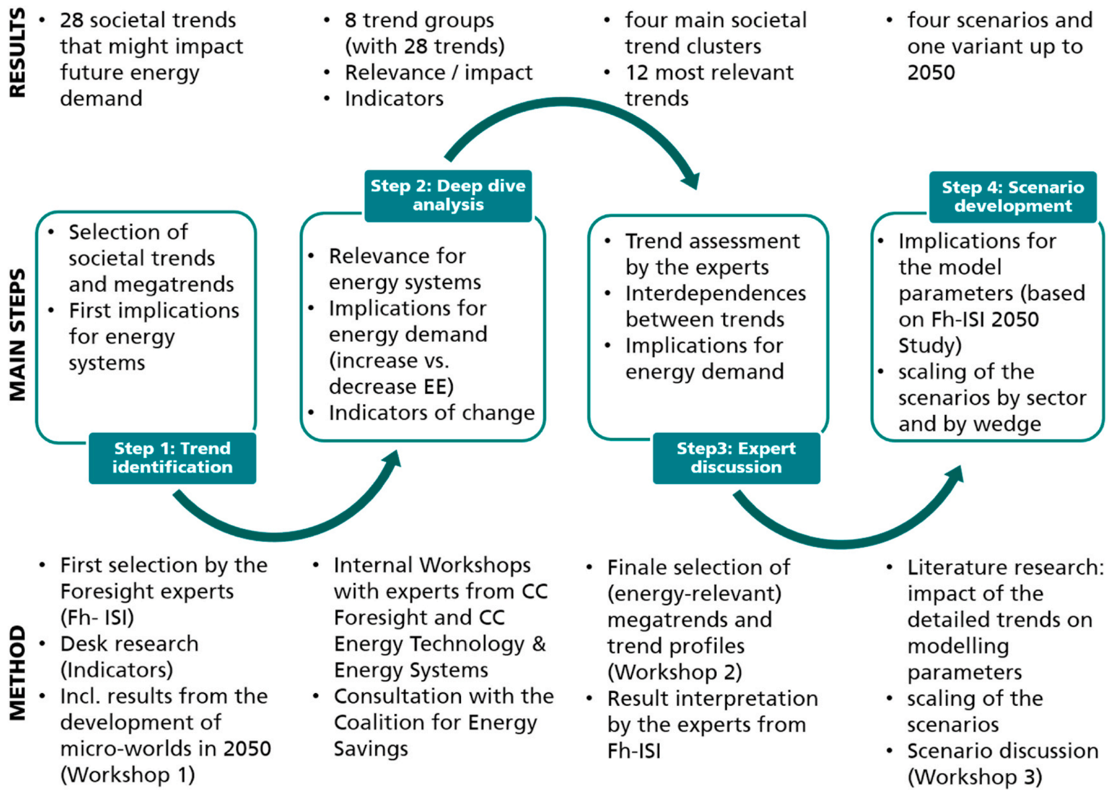

Fig. 1. Overview of the methodological process and its consecutive steps.

people 65-plus in age and increase in life expectancy or digitalization, which has an influence on the employment structure. These 60 general trends were then evaluated for their (potential) impact on the energy system. 28 societal trends were evaluated to be of major relevance for the energy system (see full list in the Annex) and were included in the following steps.

Step 2: Deep dive analysis. A deep dive analysis was carried out to assess the relevance of the societal trends for the energy system. The implications for the increase or the decrease of energy efficiency and energy demand were discussed with experts and the specific indicators of change were identified (see example in Table 3 and the full list of the selected trends resulting from step 2 in the Annex).

Step 3: Expert discussion. As the outcome of the second expert workshop, the list of trends was condensed to the 12 trends identified as being particularly relevant for future energy demand and the implementation of the EE1 principle. They were further clustered into the four main societal trend clusters presented in Table 1: “Digitalization of life”, “New social and economic models”, “Industrial transformation” and “Quality of life”. Though the development of the clusters was an iterative process with significant stakeholder and expert involvement, their definition is not set in stone and might evolve in future work.

Step 4a: Scenario development. Four scenarios to 2050 were developed with expert consultation (see Fig. 2). They were designed in comparison to a “Baseline” scenario. The left-hand side of Fig. 2 describes two techno-economic scenarios which are distinguished by the impact and strength of energy efficiency policies (high/low efforts). New societal trends are present but rather as a linear extrapolation of past trends. The right-hand side of Fig. 2 represents three scenarios with strong (non-linear) societal trends which may either lead to increasing demand or be strongly influenced by EE policies, leading to a decreasing demand. These scenarios are described in the following section in more detail.

The “Baseline” scenario[3] is based on the PRIMES projections from 2016 (European Commission, 2016a). This scenario provides the reference for the development of drivers of energy consumption. New societal trends happen in this scenario but as a rather smooth continuation of previous trends (linear societal trends).

The “Removing Market Barriers” (or “Techno-Economic”) scenario focuses on the realization of economic and near economic potentials for energy efficiency, mainly based on technical solutions. As in the “Baseline” scenario, new societal trends are included, but as a rather smooth continuation of previous trends (linear societal trends).

The following two scenarios are based on the “Removing Market Barriers” scenario. In these scenarios, the economic and near economic potentials for energy efficiency are realized such as in the “Removing Market Barriers” scenario, and, additionally, the potentials are either reduced or enhanced due to new trends.

The “New Trends Inefficient” scenario is characterized by strong non-linear societal trends due to penetration of the shared and digital economy and strong rebound effects, i.e. energy-increasing impacts of the new societal trends. By “non-linear” we mean that those trends,

[3] The “Baseline” scenario is based on the most recent projections of the European Commission with the PRIMES model (at the time this study was conducted), for the sectors as well as for the overall final energy demand. Details of these projections can be found in European Commission (2016a). The main features of this scenario are (1) final energy demand stays relatively stable and even slightly increases after 2040; (2) gross inland consumption decreases somewhat, essentially due to the penetration of renewable energy sources; and (3) (energy-related) GHG emissions decrease by about 42% compared to 2010, also mainly due to the fuel switch towards renewable energy sources. Though the reduction in GHG emissions is already considerable in the “Baseline”, overall, these projections are far from reaching the requirements of the Paris Agreement. Including all GHG emissions and comparing them with 1990, in 2050 a reduction of 48% of GHG emissions is achieved (European Commission, 2016a).

Table 3
Template for the expert feedback on the trends.

Trend	Describe relevance for the energy system	Describe how this can		Indicators of change
		increase EE	decrease EE	
Declining household size	Quicker uptake of new services Lower rate of ownership Impact on available income and consumption pattern	If it leads to rapid uptake of EE services and solutions. If it leads to urbanization and less commuting.	If it leads to more appliances and living space per capita. If it leads to poverty (capital availability).	Ownership rates and lifetime of appliances Square meters Passenger-kilometer

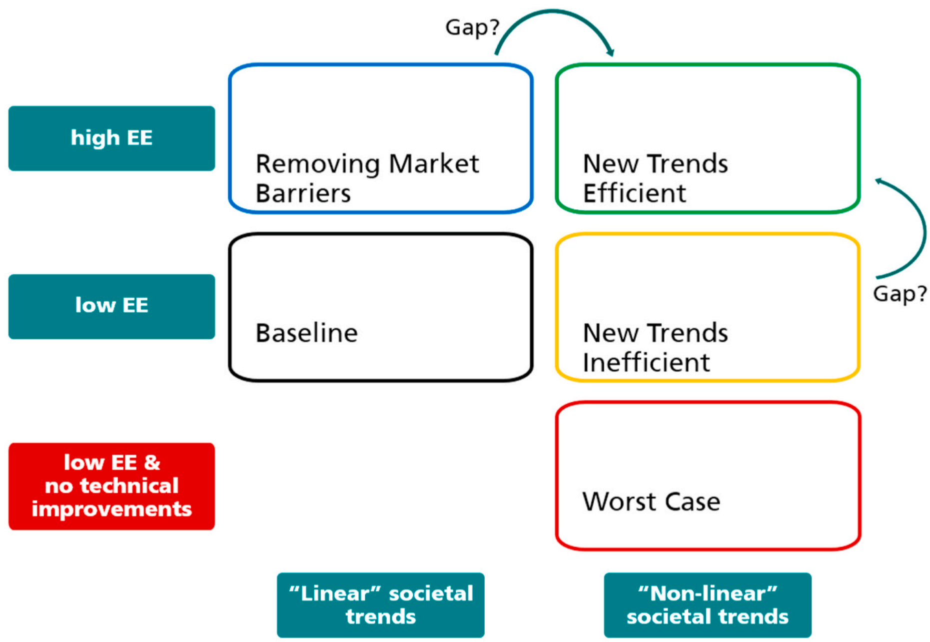

Fig. 2. The scenarios developed for the analysis of new societal trends.

although they may have been around in small niches for quite some time, suddenly receive a strong push and become part of society's mainstream.

The "New Trends Efficient" scenario is also characterized by strong non-linear societal trends. In this scenario policies are developed which act upon the new societal trends, guiding them strongly to bring forward the energy reducing impacts.

The "Worst Case" scenario has been developed in a way that new societal trends (in their increasing form) operate directly on the "Baseline". This means that in the "Worst Case" scenario economic and near economic energy efficiency potentials are not (fully) tapped by policies, while at the same time the new societal trends increase energy demand.

Step 4b: Quantifying the defined scenarios. This process included four main steps:

i) Assessing the techno-economic potentials for the "Removing Barriers Scenario", in comparison to the predefined "Baseline" scenario (European Commission, 2016a) (see section 4.1).
ii) Assessing the impact of new societal trends on energy demand - for the "New Trends Inefficient", "New Trends Efficient" and "Worst Case" scenario - through a thorough literature research on pre-existing studies. Hereby, the magnitude of the quantification given in the various studies was assessed and thereby the impact of the detailed trends on important modelling parameters were evaluated. Both energy-increasing and energy-decreasing impacts were considered.
iii) Translating the indicators of change into modelling parameters while estimating parameters that could not be obtained from the existing literature. In this step care was taken to use conservative estimates in order to not overestimate the effect of new societal trends on the energy demand in the various scenarios.
iv) Finally, the energy demand in the scenarios was scaled by sector and by end-uses[4] with the estimated parameters.

Although in these scenarios we focus on the demand side of energy use, the potentials have a major effect on gross inland consumptions, including non-energy uses. Gross inland consumption potentials are the result of material efficiency, conversion efficiency as well as final energy-related efficiency measures. The savings in gross inland consumption are thus highly influenced by the shift towards a highly efficient *electricity generation mix*. For the "Baseline" scenario the electricity mix of the European Commission (2016a) study is implemented. In the other scenarios an electricity mix is applied with a more ambitious share of renewable energy sources, and which follows the EUCO 3030 Scenario (E3MLab/IIASA, 2016) up to 2030 and then a low carbon mix up to 2050 based on an update of BMU/Fraunhofer ISI (2012), which achieves a renewable energy sources (RES) share of 92% in 2050 (see Table 4) (see Table 5).

When analyzing the studies care was taken to understand which parts of the trends were already included in the "Baseline" development and the "Removing Market Barriers" scenarios. Both scenarios already

[4] The eleven end-uses are: for private households and the tertiary sector (1) the building envelope, (2) heating and cooling, (3) lighting, (4) ICT, (5) household appliances; for the industrial sector (6) steam and hot water, (7) electric drives, (8) system optimization; and for transport (9) technical improvements and (10) E-Mobility. All saving potentials not covered by the ten specific end-uses subsumed in the "estimated wedge".

Table 4
Low-carbon electricity generation mix.

	2010	2020	2030	2040	2050
RES (without Biomass)	17%	30%	45%	56%	66%
Biomass	4%	6%	9%	18%	26%
Heating Oil	3%	1%	0%	0%	0%
Natural Gas	24%	17%	11%	9%	8%
Solids	25%	23%	13%	7%	0%
Nuclear	28%	23%	22%	11%	0%

Note: The shares refer to gross electricity generation. Until 2030 this mix stays identical to the electricity mix in the EUCO 2030 scenario of E3MLab/IIASA (2016); afterwards it is extrapolated based on BMU/Fraunhofer ISI (2012).

Table 5
Main indicators of the different scenarios.

	Final energy demand in 2050 in Mtoe (% change compared to "Baseline")	Gross inland consumption in 2050 in Mtoe (% change compared to "Baseline")	Energy-related GHG emissions in 2050 in Mtoe (% change compared to "Baseline")
"Baseline" scenario	1085.9	1491.6	2175.5
"Worst Case" scenario	1545.7 (+42%)	1695.4 (+14%)	2866.5 (+32%)
"New Trends Inefficient" scenario	737.3 (-32%)	829.8 (-44%)	1076.4 (-51%)
"Removing Market Barriers" scenario	533.1 (-51%)	600.0 (-60%)	778.2 (-64%)
"New Trends Efficient" scenario	360.6 (-7%)	405.8 (-6%)	526.4 (-6%)

include a part of the new societal trends, which can be considered the continuation of developments of the past.

4. Assessing the techno-economic potentials and the impact of new societal trends on energy demand

This section presents an overview of energy efficiency potentials in the four non-baseline scenarios ("Removing Market Barriers", "New Trends Efficient", "New Trends Inefficient" and "Worst Case") and possible contributions of the new societal trends to an increase or decrease of the energy demand in the EU until 2050 and thereby to its emission reduction targets.

4.1. "Removing Market Barriers" (or "techno-economic") scenario

The "Removing Market Barriers" scenario is defined as a scenario in which currently existing market barriers to implement the EE1 principle are removed and policies implemented in a way that the energy efficiency first principle is realized (European Commission, 2016b). This scenario is based on current projections for central drivers for energy demand (such as sectoral GDP, population growth and kilometers travelled (European Commission, 2016a)). Within this scenario techno-economic energy efficiency potentials are realized in all sectors. Techno-economic efficiency potentials are hereby defined as potentials for which technical solutions already exist and which are, at the time of investment (nearly) cost-effective (i.e. additional investment and life-cycle costs are smaller than financial savings through avoided energy costs (Fraunhofer ISI, 2014; Fraunhofer ISI, 2009; Brugger et al., 2019). To assess the cost-effectiveness, assumptions were made based, amongst others, concerning the development of investment costs as well as energy prices over time. Furthermore, only 'realistic techno-economic potentials', rather than theoretical potentials were considered (e.g. considering the technology stock with lifetimes and reinvestments cycles of technologies for the time of adoption, rather than independent technology diffusion curves) (Fraunhofer ISI, 2014; Fraunhofer ISI, 2009). Additionally, this scenario includes a contribution of enhanced energy efficiency in energy conversion and in energy end-use to gross inland consumption savings by 2050 and utilizes the electricity mix presented in Table 4.

4.1.1. Methodology for assessment

Fig. 3 provides an overview for the methodological approach that was taken to evaluate the energy efficiency potentials. The techno-economic saving potentials are assessed in a bottom-up approach. Central inputs are the technological and policy database of the ODYSSEE-MURE (2021) project, as well as national and EU statistics on activity levels (European Commission, 2016a). Based on a detailed technological structure, the saving potentials that arise through energy efficient technologies (*Demand Technology Database*) under certain framework conditions, such as activity levels and policies (*Scenario Database*), were assessed bottom-up for each of the four demand sectors under study (residential, transport, industry and services).[5]

The potentials in the original study by Fraunhofer ISI (2009, 2014) were determined based on the baseline energy demand projection of the European Commission from the year 2008 (European Commission, 2008). To take into account the current projections of energy demand drivers up to 2050 and the fact that time has moved on (with parts of the energy efficiency potentials having been realized by policy measures and parts having been "lost" for energy efficiency purposes, as investments were made in less efficient technologies), two adjustments were made:

Firstly, the potentials were scaled to the projections of the "PRIMES reference scenario" of the European Commission (2016a). Here the saving potentials were adjusted considering the updated final energy demand as well as changes in activities and altered energy intensities per sector. Secondly, potentials that were already realized between 2009 and 2016 are deducted from the previously identified potentials. Thus, a decrease in potentials in some of the sectors is the result of a combination of decreasing activities and/or already realized potentials, while increasing potentials can be traced back to higher activity projections. Thirdly, in the original study by Fraunhofer ISI (2009), the quantification of energy saving potentials was assessed up to 2030. These potentials were extrapolated up to 2050.

The saving potentials identified are cost-effective, as well as nearly cost-effective technical potentials rather than theoretical potentials (see Fraunhofer ISI, 2009; Fraunhofer, 2014 for more details). Cost-effective energy-saving potentials depend on the future development of drivers such as the economic or social development (e.g. the future GDP, population growth, stock of existing buildings, etc.). The drivers underlying the present scenario are the ones underlying the reference scenario of the European Commission (2016a) study.

With regard to the cost-effectiveness of efficiency technologies, only economical technologies are selected (i.e. the financial savings that an investor or end-user can expect through the fuel savings exceed his or her additional investments required to implement the efficiency technology) or at least near-economical ones, in order to include only technologies that are likely to reach market maturity. The latter ones are chosen in such a manner that the energy system costs do not exceed the present energy system costs. The potentials are analyzed for all eleven end-uses. Each of these end-uses includes specific energy efficiency options and the underlying technologies, which can be addressed by individual policy measures.

[5] The ODYSEE-MURE database can be assessed online at www.odysee-mure.eu.

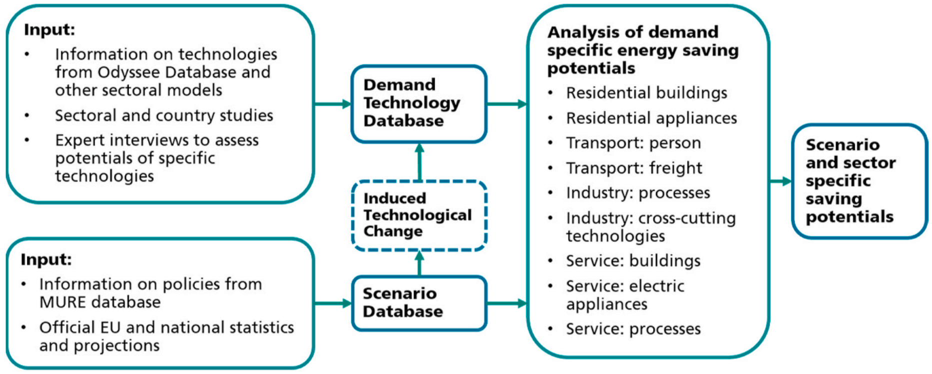

Fig. 3. Scheme for the evaluation of energy efficiency potentials (adapted from Fraunhofer ISI, 2009).

4.1.2. Overall saving potentials

In the following section it will be shown how final energy demand and gross inland consumption (including non-energy uses) as well as energy-related CO2-emissions can be reduced when techno-economic potentials are realized in all sectors.

4.1.2.1. Overall final energy demand saving potential. The total final energy demand (FED) in the reference scenario ("PRIMES, 2016" baseline) of the European Commission (2016a) peaks in 2005 and decreases until 2030. Afterwards it is expected to increase slightly. Overall, between 2000 and 2050 a decrease of 4% is projected.

Compared to this baseline development, final energy demand could potentially be reduced through realizing techno-economic potentials by 51% in the year 2050. Fig. 4 shows that households and the tertiary sector could deliver 22% (end-uses 1–5), the industry sector contributes 7% (end-uses 6–8) and the technical improvements in the transport sector together with a notable shift towards electric vehicles (end-uses 9 and 10) – about 14%. Furthermore, the "estimated wedge" contributes about 7% to the savings and subsumes – among others – low impact industry savings, and certain appliances in the tertiary sector. Overall, 14% of final energy demand reduction (about 1/3 of the total savings) can be realized solely through building envelope measures. Here the agriculture sector is included in the remaining final energy demand in the tertiary sector.

4.1.2.2. Overall gross inland consumption saving potential. Based on a decrease of final energy demand in the "PRIMES 2016" baseline, the gross inland consumption (including non-energy uses) will also decrease slowly but steadily. In the baseline scenario it is expected to be 15% lower in 2050 as compared to 2010.

The gross inland consumption saving potentials, as shown in Fig. 5, are divided into "conversion savings" triggered by the shift towards a highly-efficient, mainly renewable energy-based electricity supply system (see Table 4) and "final energy savings" due to exploiting the final energy saving potentials described above.

Gross inland consumption can be reduced by up to 20% by 2050 due

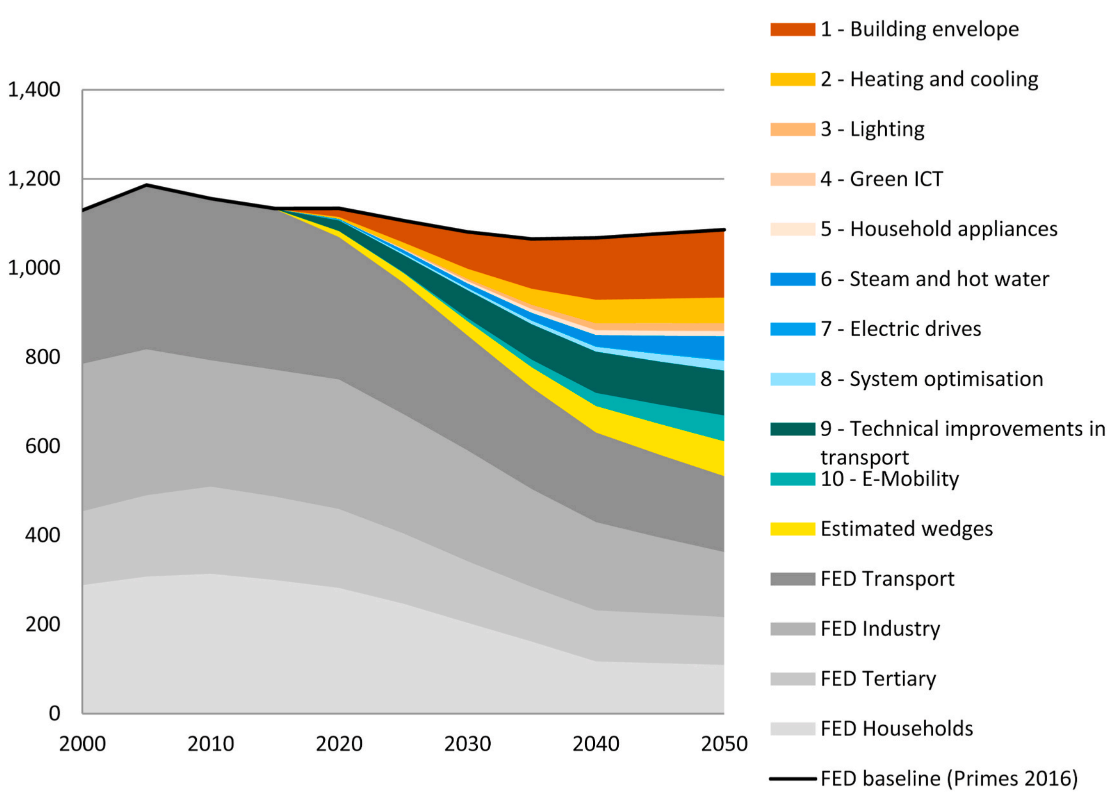

Fig. 4. "Baseline" (PRIMES, 2016) and "Removing Market Barriers" scenarios: Overall final energy demand (FED) and final energy savings (in Mtoe).

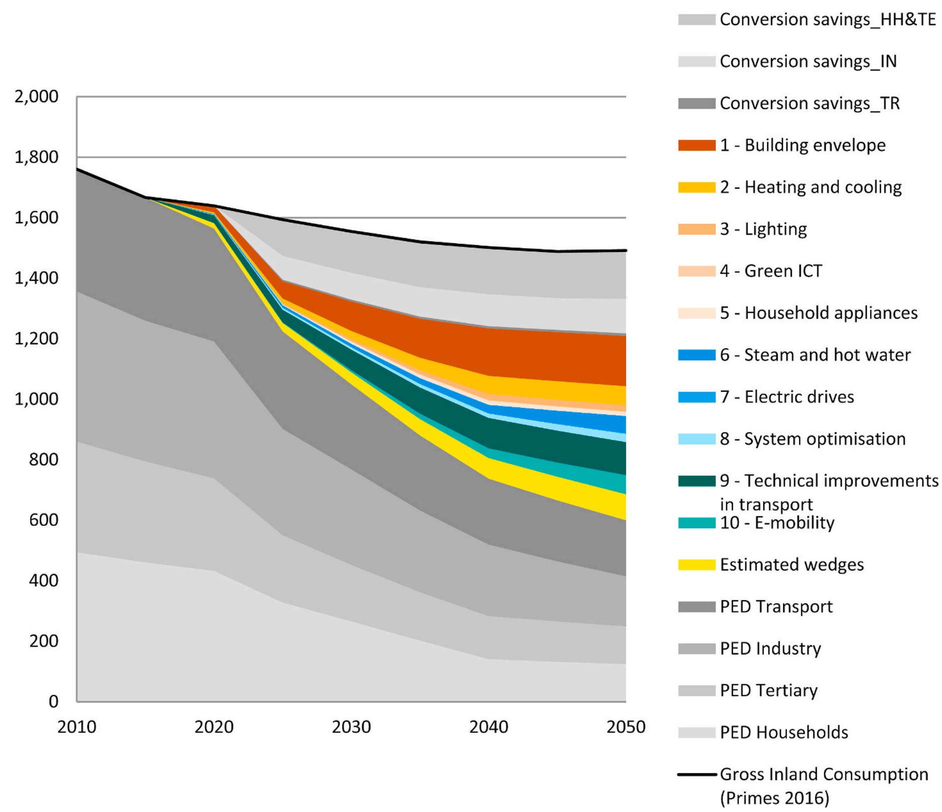

Fig. 5. "Baseline" and "Removing Market Barriers" scenarios: Gross inland consumption (including non-energy use) and saving potentials for all sectors (in Mtoe).

to conversion savings. The transport sector's contribution here is negligible since it does not benefit from an increase in conversion efficiency (e.g. for oil products). Final energy-related savings imply an additional 40% reduction in gross inland consumption, making a total of 60% of the gross inland consumption avoidable.

4.1.2.3. Energy efficiency contribution in GHG emission reductions. In the "PRIMES 2016" baseline, GHG emissions are projected to decrease drastically by 43% between 2010 and 2050 (Fig. 6). This is based on the fact that electricity is increasingly generated using low-carbon generation technologies. The additional emission reduction potential due to "conversion savings" lies at 21% in 2050 compared to the baseline, 13.5% of which are due to the increase of electric vehicles in passenger transport.

The overall contribution from energy efficiency measures related to final energy lowers GHG emissions by an additional 43% compared to the baseline emissions. This can be translated into a 79% emission reduction compared to the 2010 level and 81% emission reduction compared to the 1990 level. It has to be noted however, that these figures represent only energy-related GHG emission reduction potentials and do not reflect measures in other areas.

4.1.3. Analyzing the sectoral saving potentials: the household sector as an example

The "Removing Barriers Scenario" answers the question as to what extent final energy demand can be reduced via the realization of (nearly) cost-effective energy efficiency potentials. The techno-economic potentials were modelled with a bottom-up approach (Fraunhofer ISI, 2009; BMU/Fraunhofer ISI, 2012; Fraunhofer 2014), based on the FORECAST model family and have been updated in order to account for potentials realized and lost since the initial study. The results of the bottom-up modelling of the techno-economic potentials are explained using the household sector as an example.

According to "PRIMES 2016", the baseline final energy demand in the household sector is projected to have peaked in 2010 and to decline from 2010 until 2030, with a small increase afterwards. Final energy demand is projected to again reach the level of 2025 in the year 2050 (~290 Mtoe). However, major final energy saving potentials were identified, which can lead to a reduction in final energy demand of 63% in 2050 compared to the baseline development (Fig. 7).

More than half of these savings are related to the building shell refurbishment of existing buildings, with the refurbishment of old buildings (25%) and the refurbishment replacement of heating system in existing buildings (13%). Furthermore, 12% of savings can be realized in the construction of new buildings. The savings in sanitary hot water (4%), efficient lighting (3%) and electric appliances (4%) contribute to a significantly lesser extent to the overall savings.

4.2. "New Trends Inefficient", "worst case" and "New Trends Efficient" scenarios

The "New Trends Inefficient", the "Worst Case" and the "New Trends Efficient" scenarios complement the "Baseline" and "Removing Market Barriers" scenarios, which take structural and societal changes and their (increasing or decreasing) impacts on energy consumption more explicitly into account. They are contrasting scenarios: in particular, the "New Trends Inefficient" scenario and the "Worst Case" scenario combine the energy-increasing impacts of these trends while the "New Trends Efficient" scenario supposes that strong energy efficiency policies enhance the decreasing impacts of the trends concerning energy consumption. De facto, increasing and decreasing impacts may be observed at the same time.

4.2.1. Methodology for assessment

The assessment of energy efficiency potentials in "New Trends Inefficient", the "Worst Case" and the "New Trends Efficient" scenarios relies on the following steps: (1) analyzing the impact of societal trends on energy consumption through a thorough literature review of existing

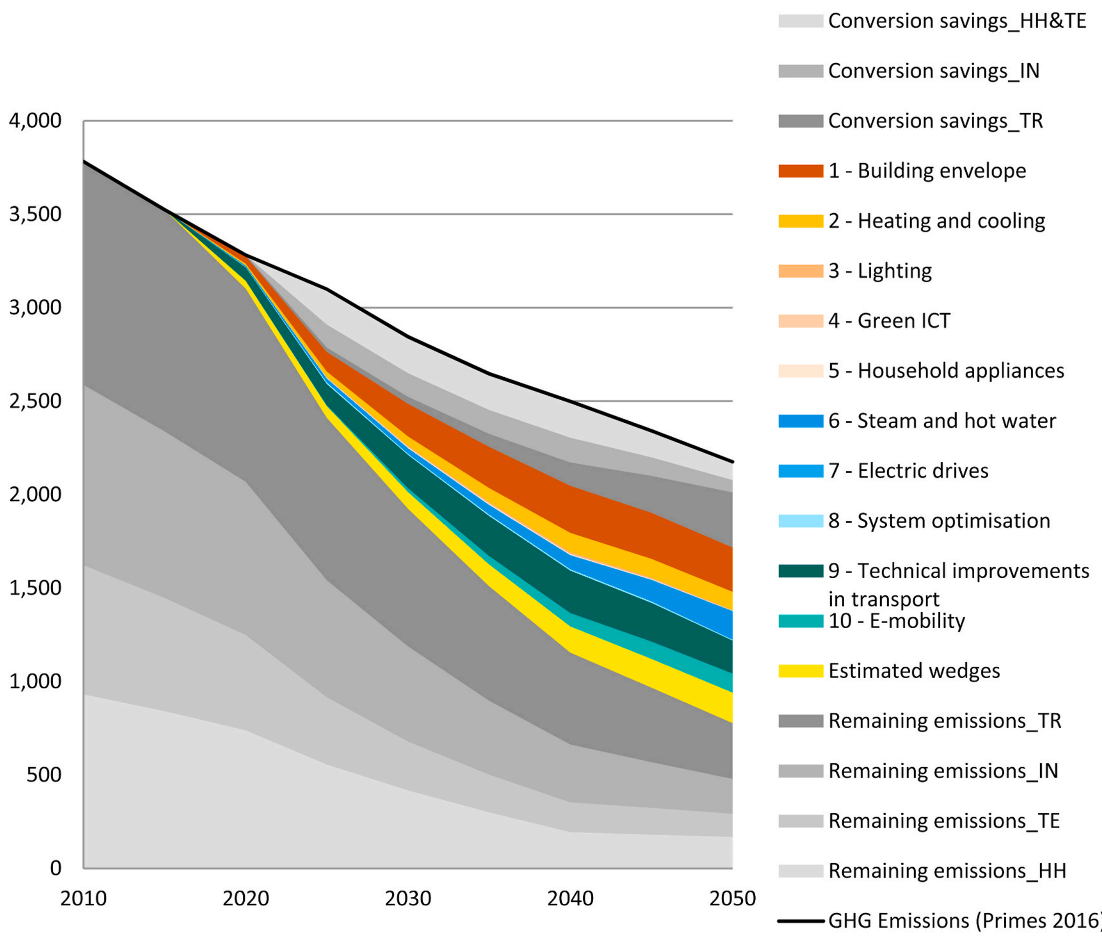

Fig. 6. "Baseline" and "Removing Market Barriers" scenarios: Energy-related GHG emissions resulting from final energy savings (in Mt CO2-equivalent).

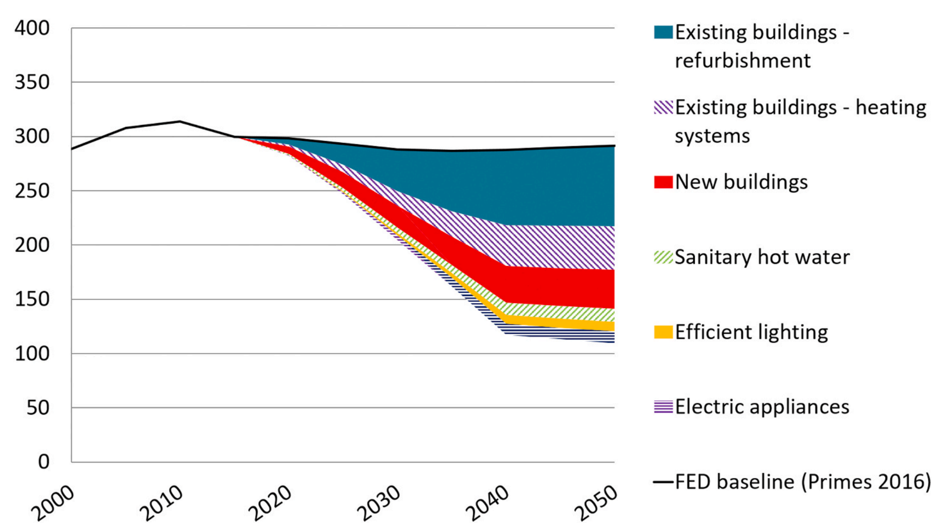

Fig. 7. "Baseline" and "Removing Market Barriers" scenarios: Final energy demand and energy savings potentials by end-use in the household sector (in Mtoe).

studies. (2) Assessing the qualitative and quantitative impacts given in the various studies and thereby evaluating the impact of the detailed trends on important modelling parameters of the various end-uses set up in the "Removing Market Barriers" scenario. Both energy-increasing and energy-decreasing impacts were considered (see example in Table 3). When analyzing the studies, care was taken to understand which parts of the trends were already included in the "Baseline" and the "Removing Market Barriers" scenarios. It should be recalled that both already include parts of the new societal trends, which can be considered the continuation of developments of the past. The "Worst Case" scenario is building up the effect of energy-increasing impacts on the "Baseline" scenario, and is thus based on the assumption that the techno-economic potentials are not realized and that additionally trends will unfold in an energy-increasing manner. (3) Translating the impacts into modelling parameters. (4) Estimating open model parameters. Here conservative estimates as to the impacts of such trends were applied. Furthermore, the model parameters for the end-uses need to account for double-counting of certain mechanisms across end-uses. Care was taken here to eliminate instances of double-counting among the different societal trends, but more in-depth analysis could better separate such overlapping impacts. Finally, (5) scaling of the scenarios by sector and by end-use with the estimated parameters was implemented.

4.2.2. Overall saving potentials

Fig. 8 shows the overall final energy demand within the various scenarios. In addition, Fig. 8 indicates to which extent the four main societal trend clusters contribute to the decreasing final energy demand from the "Removing Barriers" scenario (mere techno-economic potentials) to the "New Trends Efficient" scenario. Note that for example the low impact of the industrial transformation is due to the fact that most changes within this transformation are (nearly) cost-effective techno-economic changes, and thus already included to a large degree in the "Removing Market Barriers" scenario.

The main findings from the analysis of the total final energy demand are the following: new societal trends without any accompanying strong energy efficiency policies ("New Trends Inefficient" scenario) could diminish the effect of the realized techno-economic potentials for final energy demand to a 32% reduction (as compared to the "Baseline" in 2050). If, on the one hand, the new societal trends were to manifest the energy increasing trends without the realization of the techno-economic potentials ("Worst Case" scenario), the final energy demand could be strongly increased by up to 42% above the "Baseline". On the other hand, new societal trends supported by strong energy efficiency policies ("New Trends Efficient" scenario) could decrease final energy demand further (decrease by 67% compared to the "Baseline" in 2050).

The four trend clusters hereby describe the difference between the "Removing Barriers" and the "New Trends Efficient" scenarios. "Digitalization of Life", "New Social and Economic Models" as well as "Quality of Life" each contribute to this further reduction of 172.5 Mtoe with a share of approximately 30%, while the "Industrial Transformation" only contributes with a reduction share of 5% (for more details see Table 6 below).

The gross inland consumption and the (energy-related) CO_2-emissions are based on the final energy demand and the low-carbon electricity mix shown in Table 4. The resulting gross inland consumption and CO_2-emissions within the four scenarios are visualized in Fig. 9 and Fig. 10.

4.2.3. Sectoral saving potentials: the household sector as an example

For the household and tertiary sectors the following main impacts of the new societal trends on energy consumption and scenario parameters were identified to be relevant, in addition to the realization of techno-economic potentials:

in the "New Trends Inefficient" scenario (increasing impacts on energy consumption):

- building automation and interconnection of appliances increase the energy demand of buildings.
- despite a widespread awareness, consumers face increasing energy demands (e.g. due to changes in comfort levels).

in the "Worst Case" scenario (increasing impacts on energy consumption and techno-economic potentials not realized):

- the same energy-increasing effects as in the "New Trends Inefficient" scenario
- additionally, the techno-economic potentials are not realized (e.g. renovations that are economic were not implemented)

Table 6
Contributions of the four trend clusters to the reduction of FED beyond techno-economic potentials in 2050.

	Total[a]	Households	Services	Industry	Transport
FED in "Removing Market Barriers" scenario (in Mtoe)	533.1	109.5	82.0	145.8	170.2
FED in "New Trends Efficient" scenario (in Mtoe)	360.6	73.4	55.5	125.1	81.1
Difference between the two scenarios (in Mtoe)	172.5	36.1	26.5	20.7	89.1
Reduction contribution by trend cluster in Mtoe (in % of difference)					
Digitalization of Life	49.0 (28%)	8.1 (22%)	7.9 (30%)	3.9 (19%)	29.0 (33%)
New Social and Economic Models	60.3 (35%)	13.3 (37%)	9.5 (36%)	7.4 (36%)	30.0 (34%)
Industrial Transformation	9.3 (5%)	0.0 (0%)	0.0 (0%)	9.4 (45%)	0.0 (0%)
Quality of Life	54.1 (31%)	14.8 (41%)	9.0 (34%)	0.0 (0%)	30.0 (34%)

[a] Totals include the values for agriculture, which are not part of the sectoral analysis.

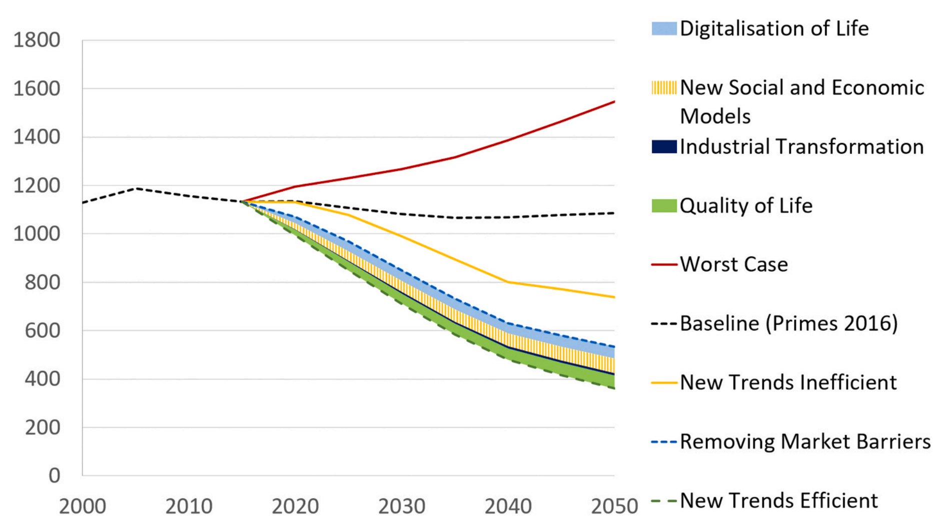

Fig. 8. Final energy demand (EU28) in the four scenarios and the baseline (in Mtoe) and the contribution of four main trend clusters in the case of the "New Trends Efficient" scenario.

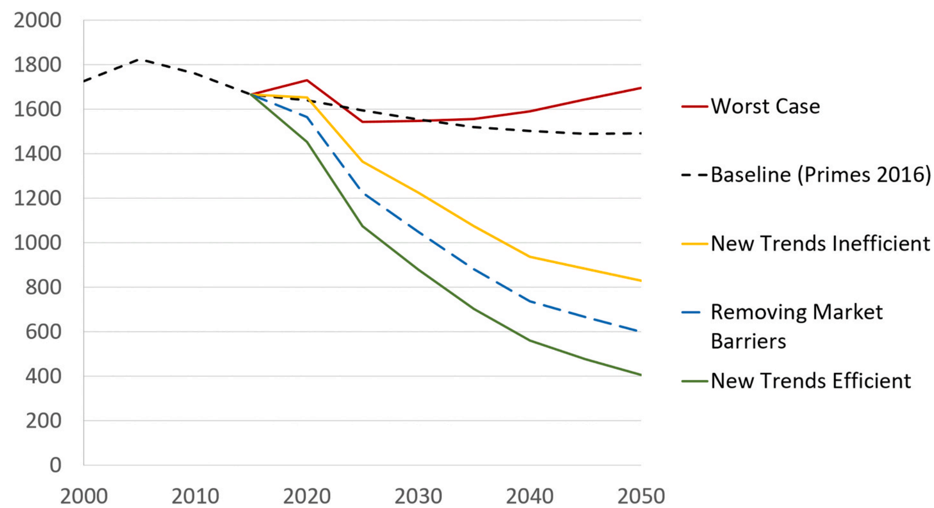

Fig. 9. Gross inland consumption (in Mtoe) in the four scenarios and the baseline (EU 28).

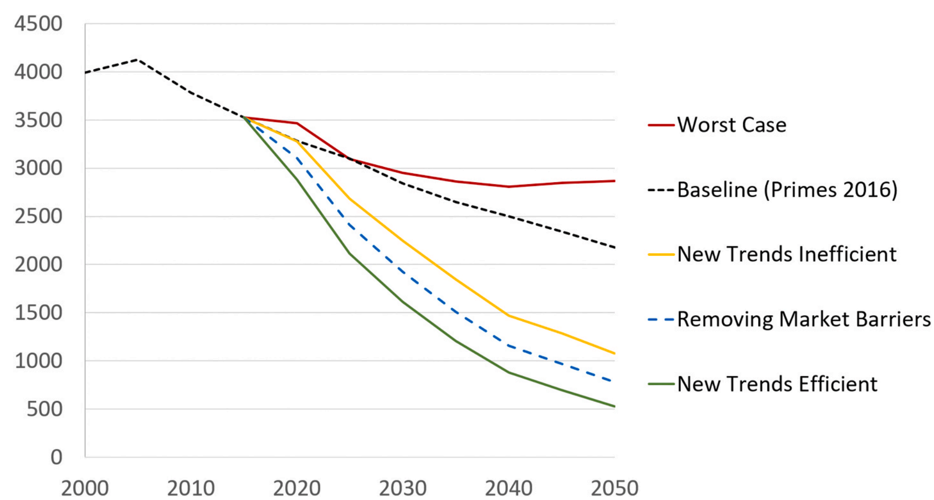

Fig. 10. Energy-related GHG emissions (in Mtoe) in the four scenarios and the baseline (EU28).

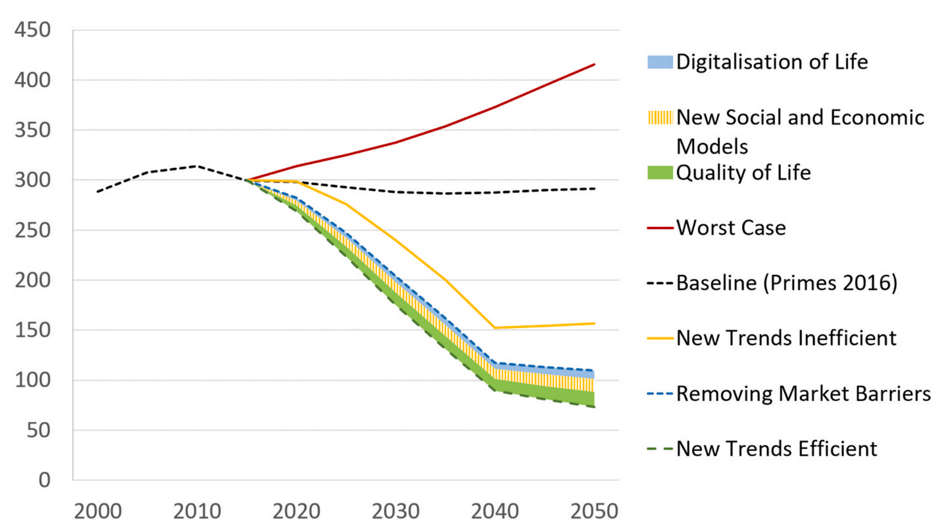

Fig. 11. Final energy demand in the household sector (EU28) in the four scenarios and the baseline (in Mtoe) and the contribution of the four main trend clusters in the case of the "New Trends Efficient" scenario.

in the “New Trends Efficient” scenario (decreasing impacts on energy consumption):

- building automation increases consumer awareness.
- decentral generation of electricity raises awareness regarding the value of energy.
- urbanization contributes to smaller (individual) living spaces and adapting them to the living context.
- awareness about personal carbon footprint impacts consumer choices on buildings and appliances.

Behavioral choices such as the adaptation of space to the living context, awareness of the personal carbon footprints and decentral generation of electricity (supported by policy settings) contribute to the “New Trends Efficient” scenario. Results for final energy demand (EU28) in the four scenarios are provided in Fig. 11.

Fig. 11 shows that the four trend clusters can lead to additional saving potentials that go beyond the mere techno-economic saving potentials of the “Removing Market Barriers” scenario. If all four trend clusters would unfold in a beneficial manner, the FED in the “New Trends Efficient” scenario could be xx Mtoe below the FED in the “Removing Market Barriers” scenario. 22% of which can be attributed to the cluster of digitalization, 37% to the cluster of New Social and Economic Models and 41% to the cluster Quality of Life. The cluster of Industrial Transformation does not lead to any additional potentials for the private households.

5. Main findings and limitations of the study

The main indicators of the different scenarios are summarized in Table 5. These findings suggest, that the new societal trends could indeed have a major impact on future energy demand. A large bandwidth of drastically increasing FED in the “Worst Case” scenario and substantial reductions beyond the techno-economic potentials in the “New Trends Efficient” scenario is observed. Furthermore, the results of the “New Trends Inefficient” scenario show, that new societal trends can substantially reduce energy savings due to direct and indirect rebound effects. This goes to show that new societal trends are often not inherently positive or negative for future energy demand, but that the impacts can substantially differ depending on the way they unfold, which (amongst others) highly depends on accompanying policies.

Table 6 summarizes the contribution of the four trend clusters to the reduction of FED within the different sectors, beyond the techno-economic potential in the “Removing Market Barriers” scenario. Overall, the “Digitalization of Life” (28%), the “New Social and Economic Models” (35%) and the “Quality of Life” (31%) contribute with approximately equal shares to the reduction. While the “Industrial Transformation” only contributes with 5%. Further we observe that the three former clusters contribute to relatively equal amounts to the reduction potential in the services and transport sector. While the “Quality of Life” (41%) plays a distinctively more important role in the household sector, with the “Digitalization of Life” (22%) being still quite important, but not as prominent as for the total FED reduction (28%). Not surprisingly, in the industrial sector the “Industrial Transformation” (45%) contributes by far the most to the reduction potential, followed by “New Social and Economic Models” (36%) and “Digitalization of Life” (19%).

This exploratory work comes with some limitations that have to be kept in mind. Firstly, since European ambitions develop rather rapidly, the latest updates of the energy efficiency goals and the accompanying policy framework (notably the reviewed Renewables Directive) could not be taken into account. Secondly, this analysis is based on cost-effective potentials previously identified (BMU/Fraunhofer ISI, 2012; Fraunhofer ISI, 2009; Fraunhofer ISI, 2014). Although all potentials were updated considering structural changes, altered activities and updated energy intensities, some haziness cannot fully be excluded. Thirdly, the potentials were updated based on “PRIMES 2016”. By doing so, the assumptions regarding structural and lifestyle changes (or the lack of the same) as well as the changing extent of activities and energy intensities are adopted from “PRIMES 2016” as well. Fourthly, limitations arise due to the current availability of data and studies. For many trends no previous studies exist, not even ones which determine the qualitative effects of a trend on the energy consumption (e.g. consumer, financing, urbanization) and had to be completed by own expert estimates regarding impacts. Specifically, there is quite often no quantification of these trends yet. A sensitivity analysis considering differences of the estimated parameters would be an important next step, until the data is more comprehensively available. Fifthly, existing studies are often not transparent in their baseline assumptions. Some trends were assessed on other jurisdictions, e.g. the US or single EU member states. Therefore, parameters needed to be adopted to the EU context. Specific EU studies may enhance the validity for the European context. Furthermore, as mentioned previously, the assessment of the effects on energy demand of the various mechanisms has to account for double-counting. A multiplication of the effects (rather than an addition) was chosen as a more conservative calculation method in order to minimize remaining double-counting effects. More studies on individual trends, and especially their interplay, are required in the future to gain more certainty concerning the quantitative impacts.

6. Conclusion and policy implications

Efficiency gains play a crucial role in realizing the EU climate goals. However, these efficiency gains do not by themselves lead to a reduction of energy demand. One example is the transport sector in which the potential reduction of energy demand by increasing efficiency is counteracted by an ever-growing demand of private car transport and larger vehicles (IEA, 2019). The same can currently be observed in the area of digitalization in which major efficiency gains in data centers are currently only able to offset the rising demand (Masanet et al., 2020).

This paper aimed at opening up the discussion of how energy demand might change through new societal trends. Based on these trends, it analyzed four energy demand scenarios developed for 2050 (“Baseline”, “Removing Market Barriers”, “New Trends Efficient”, “New Trends Inefficient” and “Worst Case”). As the various scenarios depict in a stylized manner, new societal trends could unfold in a way that would further substantially decrease energy demand beyond merely realizing the techno-economic potentials if strong energy efficiency policies, expressed through the Energy Efficiency First (EE1) principle, guide individual and policy decision-making in a beneficial way. However, the effects of the new societal trends could also counteract efficiency gains in a way that leads further away from achieving the EU goals for energy efficiency and climate neutrality in 2050.

The EU proposed EE1 as a fundamental principle applied to policy-making, planning and investment in the energy sector. The EE1 principle is now gaining increasing visibility in European energy and climate policy (European Climate Foundation, 2016). Put briefly, the concept of EE1 prioritizes investments in customer-side efficiency resources (including end-use and supply side energy efficiency and demand response) whenever they would cost less, or deliver more value, rather than investing in energy infrastructure, fuels and supply alone (ENEFIRST, 2020; European Commission, 2016b). Although the Energy Union Strategy has recognized energy efficiency as a resource in its own right at the same level as generation capacity and the EE1 as a guiding principle has been brought forward, previous studies suggest that numerous barriers still impede this principle from being streamlined and the benefits of energy efficiency from being adequately taken into account in financial and political planning and decision-making (BMU/Fraunhofer ISI, 2012; Fraunhofer ISI, 2009; Schleich, 2009; Schleich and Gruber, 2008). The results of this study show that the path that final energy demand will take in the years to come is less than certain and will depend not only on the realization of techno-economic potentials, but also to a vital degree on how societal trends will unfold. These trends can have an impact on energy efficiency improvements and contribute to a decrease or increase of energy consumption beyond the linear trends. In particular, an increase in energy consumption might be the result of new societal trends that are not accompanied by policies strongly implementing the EE1 principle. While the current paper aims at raising awareness of the large effects that the new societal trends might have on future energy demand, it will be crucial to further intensify the endeavor of studying not only the cost-effective potentials, but also to further quantify the effects, including cross-sectoral effects, that societal trends will have on future energy demand. This might ultimately inform policy-makers how European policies have to be designed in order to shape political, commercial and individual decision-making in a way that further decreases energy demand rather than counteracts efficiency gains.

To summarize: the work presented in this paper is pioneering work. It collects information on the relationship of new societal trends to the best of present knowledge and closes the gaps with estimates. More studies on individual trends, as well as on the interplay between them, are required in the future to gain more certainty on the quantitative impacts. Estimates, both upward and downward, are carried out in a conservative way to not overestimate the impacts of the new societal trends for which data availability is still challenging.

CRediT authorship contribution statement

Heike Brugger: Conceptualization, Methodology, Formal analysis, Writing – original draft, Project administration. **Wolfgang Eichhammer:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Supervision, Funding acquisition. **Nadezhda Mikova:** Writing – original draft, Writing – review & editing. **Ewa Dönitz:** Conceptualization, Methodology, Formal analysis.

Declaration of competing interest

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

Acknowledgements

This study was supported by "The Coalition for Energy Savings" as part of the project "Developing a 2050 Energy Efficiency Vision". Furthermore, this work has received funding from the European Union's Horizon 2020 research and innovation programme under the project NewTRENDs with the grant agreement no. 893311.

Annex

The 28 trends resulting from step one of the methodological process.

Cities

1. Villages as pioneers in shaping the post-growth society
2. The global urban middle class – tipping the scales of sustainable urban development?
3. The growing importance of the region in the global economy
4. Urban governance – solving global challenges locally in cities
5. Social cohesion – the cement of 21st-century societies?

Industries

6. 29. Reindustrialization
7. 39. New paradigms of economic growth and social prosperity
8. 45. Growing importance of enterprises in emerging economies

Lifestyle

9. More attention being given to social innovations
10. Rebound effect: underestimated paradox of sustainability
11. Self-optimization of people
12. Gamification – persuasive games in ever more areas of life
13. Do-it-yourself 2.0
14. A new culture of exchange is becoming established
15. Personal footprint – more responsible consumption
16. Slow consumption as a countertrend to fast fashion
17. Rediscovery of the commons
18. Social disparities – fault lines of global development
19. Future European integration scenarios

Health

20. Noise: the ignored environmental and health problem

Land use

21. Economic activity in extreme climatic regions is being stepped up
22. Reconquering the public space

Time use

23. Time sovereignty

Banks

24. Crowdfunding is becoming established as an alternative financing model
25. Ethical and value-based financial services
26. Impatient investors - the drying-up of long-term capital
27. Public finances: from voluntary commitment to paralysis?
28. New requirements for material flows for consumer goods have a delayed impact on the environment and disposal systems

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