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ORIGINAL ARTICLE

Revisiting SDG-7 under energy efficiency vision 2050: the role of new economic models and mass digitalization in OECD

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Abstract Policies on reducing energy demand should incorporate the newly formed economic models, digitalization, and consumer awareness trends. Therefore, this study analyzes the interaction of the three trends with SDG7 under energy efficiency vision 2050, measuring the energy efficiency of OECD from 2005 to 2017 to enable this inclusion. In this context, four new trends expected to shape future energy demand are identified through extensive consultation with experts from South Asian countries by developing future power demand for the year of 2050. Consequently, the results show a crucial impact of such trends on a future power demand that exceeds the economic potential of techno. Hence, the best-case scenario, "New Trends Efficient," reduces final energy demand by 78% compared to the South Asian "Baseline" scenario in 2050, whereas the "Worst Case" scenario increases final energy demand by 35%. Therefore, Austria and Korea have the highest energy efficiency score of 0.76 and 0.75, whereas Canada and Chile have the lowest energy efficiency score of 0.41 and 0.42. This paper discusses the ability of digitalization and energy consumer awareness trends in shaping the future energy demand based on SDG 7, emphasizing the importance of energy efficiency vision 2050 in policymaking for effective acquisition.

Keywords Energy efficiency · SDG 7 · Vision 2050 · Energy scenarios · South Asian countries

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Introduction

The sustainable development goal number 7 (SDG-7) on affordable and reliable energy provision aims to increase public attention at large demanding the energy generation and provision system to be efficient in production and distribution (Jin et al., 2021). In this context, recent studies assess SDG number

7 with energy efficiency presenting different solutions (Raberto et al., 2019). Similarly, the developed and emerging economies face a downturn and drift in energy system due to COVID-19 outbreak (Azhgaliyeva et al., 2020), which changes digitalization, consumer awareness, and national economic models, considering various conditions regarding energy efficiency (Agyekum et al., 2021, and Zhang et al., 2021). Moreover, literature fails to enable policymakers and other stakeholders of energy sector with substantial guidelines. However, recent studies attempt to understand the level of awareness among consumers along with digitalization and new economic models to achieve SDG 7 under energy efficiency vision 2050, which is encouraged by the need to understand the revisited outcomes better to effectively apply the suggested policies (Han et al., 2021).

Furthermore, the new worldwide sustainable development goal encompasses subjects, such as poverty eradication and improvement in health and quality of life to mitigate climate change and inequality (He et al., 2018). Consequently, the 17 priorities of Sustainable Development Goals and their objectives are integrated and indivisible, and should be addressed from all angles to work on the 2050 Agenda (Chen et al., 2018). Therefore, the main objectives of SD7 include sustainability and accessibility and the science community helps decision leaders in comprehending how these issues intersect through link analysis exploring connections between this mission and other SDG objectives (Sun et al., 2020a, b). Moreover, they identify 143 synergies and 65 trade-offs in the energy systems diagram using the seven-point scale originally created to measure SDG encounters to evaluate this element. Similarly, the theory by Thacker (including electricity projects) assesses the influence of various contexts, such as political systems, climate, and technology, whereas Li et al., (2021a, b) evaluate the interdependencies of energy and SDGs, determining the measure of energy required to meet the SDGs' demands (Alemzero et al., 2020a, b, Sun et al., 2020d). In this context, both calculate electricity as an important part of the 2030 Agenda, whereas the interdisciplinary work is still under consideration. Furthermore, it is possible to achieve the goals set out in actionable terms of the sustainable development strategy, such as population growth and energy supply with investments in modern energy infrastructure. Moreover, long-term sustainability is assured only by balancing electricity demands with sustainable development goals (Zhang et al., 2020b).

Similarly, the potential consequences of society's demand for oil are anticipated by looking at the current and future changes and the "new social trends" are referred to as "niche trends" for long term and are gaining momentum owing to the new technologies and community attitudes supporting them (Sun et al. 2020d, e, f). The shared economy changes consumer and commodities ownership. As consumption is increasingly constituted by shared and connectivity consumption, ownership is concentrated. The study on the sharing economy concentrates almost solely on shared consumption patterns and, despite the considerable work it does on types of shared ownership, i.e., fractional ownership, ignores ownership. Consequently, the result is rather dubious given the present social, environmental, and economic circumstances.

According to a recent study, new economic models, mass digitalization, and the awareness of energy consumers have a significant impact on energy efficiency and its associated vision, enhancing the structural ability of the energy sector to achieve Sustainable Development Goal, which is to provide affordable and reliable energy to all (Mohsin et al., 2021). As a result, in the "Literature review" section, this research summarizes what is known in the existing literature regarding the four novel social pattern clusters described in the "Introduction" section. Furthermore, we describe how the most recent societal changes in energy are represented along with the key parameters used in the process. Moreover, the "Results and discussion" section examines recent social dynamics and the sectorial increase in energy consumption, providing a preliminary evaluation of how they interact. The "Robustness analysis" section assesses some of the challenges proposed by the solution. Finally, the "Conclusion and implications" section analyzes the existing responses to the central question and offers a theory.

Literature review

Different countries influence pollution reduction in this region under the Paris Agreement through goals and activities established by their Nationally Determined Contributions (Qi et al., 2019). In this context, numerous researches on the energy efficiency “paradox” indicate the challenge to achieve significant savings due to the decrease in the optimum standards for practical execution of energy efficiency measures (Barua et al., 2020). Moreover, obstacles, such as recurrent industry shortcomings and behavioral anomalies (e.g., stigma, meaning, motivation), prevent the application of performance interventions and demand government action to overcome these issues to reach the required rate of energy savings (Ikram et al. 2019a, b, Sun 2019). However, using current policy instruments, such as standards, economic instruments, or facts, as shown in the “Data and research framework” section, to design public interventions, seems very difficult (Sarwar et al., 2019). Therefore, public intervention must react as quickly and efficiently as possible to a recognized market weakness or obstacle, which is highly dependent on the how these policies are implemented (Zhang & Vigne, 2021). Although theory aids in policy planning, the circumstances for the implementation of energy efficiency are always second best (Brika et al., 2018), so the outcomes do not often match those predicted by current theoretical expertise. Consequently, strong analytical data is required with general trends of efficacy allowing the identification of the causes potentially responsible for the success or failure of various policy decisions (Ikram et al., 2019a; Shah et al., 2019). Hence, strategies by various organizations and entities are examined by a number of research articles, surveys, and reviews (Syafiqah & Yussof, 2018).

Till now, substantial amount of literature discusses the consequences of energy-efficient policies indicating the lack of impact by green certificates on residential price and property price in regions where property prices are lower and show only a moderate impact in higher property prices (Yang et al., 2021, W. He et al., 2020, and Muhammad Mohsin et al., 2020), whereas properties which are more expensive show higher impact. Consequently, notwithstanding reliance of literature surveys on a particular form of tool, the literature indicates direct effects of energy conservation measures on energy consumption and the price of durable goods (Mohsin et al., 2018a, b, Ikram et al. 2019a). Furthermore, literature on the results of energy management measures as a whole is absent on the reports, describing the key variables affecting the predicted factors. Therefore, this article makes use of a larger database to provide reliable results.

Moreover, this subsection discusses the sustainability of the usage of shared economy, which shows many controversies, including the feasibility and sustainability of sharing economy (Zhang et al. 2020a). It also discusses the way shared economy promotes environmental growth as well as quality of life. Although sharing economy business model shows a promising future, it is plagued by a poorly regulated marketplace (Taghizadeh-Hesary & Yoshino, 2019, and Taghizadeh-Hesary & Yoshino, 2020).

In such embryonic settings, organizations are often confronted with perplexing and contradictory institutional pressures (Clemens & Douglas, 2005), stakeholder demands, and expectations (Wang et al., 2016) and are significantly hampered if these influences are accepted (Newlands & Lutz, 2020). Similarly, the connection between sharing economy companies and its main stakeholders suffers through several friction points, such as price, safety, and job status, leading to market failures if ignored (Cohen & Sundararajan, 2015). Consequently, legitimacy is achieved only if sharing economy businesses overcome these obstacles and address stakeholder concerns.

The success of sharing economy businesses depends on maintaining and developing trust among stakeholders and is more important when businesses operate in difficult, poorly regulated institutional settings. Hence, organizations need a well-thought-out plan to maintain confidence in dealing with such demands and the methods vary from passive compliance to aggressive opposition or conflict (Oliver, 1991). Therefore, conforming to stakeholder expectations is a common organizational reaction (Clemens and Douglas, 2005; Scott, 2008), as it is the route of least resistance improving the probability of survival. Therefore, organizations prefer alternative methods covering conformity and confrontation, aberrant from conventional responses. For instance, Uber gathers consumer support against pro-consumer laws through methods, such as regulatory arbitrage and use of industry-consumer alliances, which is comparatively. Hence, popular press highlights the incidences of deviant tactics used by sharing economy.

Furthermore, the so-called sharing economy is a new business model allowing anyone, especially private individuals, to share their property or provide services through internet platforms and leading businesses, such as Uber and Airbnb provide a centralized settlement solution connecting suppliers and customers. In this context, consumers are charged of the service, which in the case of Airbnb is up to 20% of the reservation subtotal. Moreover, the five major sharing economy sectors, such as travel, vehicle sharing, finance, staffing, and music and video streaming, are expected to grow their worldwide earnings from 15 billion dollars in 2015 to up to 335 billion dollars in 2025, as stated by PwC. However, blockchain technology, which allows decentralized data storage and transmission, may disrupt traditional economic structures. Furthermore, smart contracts, which may automate operations in a decentralized way, can be deployed as part of these blockchains.

Similarly, some analysts agree how shared economy should minimize inequity and drive down prices (Zhou et al., 2020), whereas others state the lack of impact on the long-term sustainable development of an economy by sharing economy. For instance, sharing economy businesses promote and entrench economic models. Moreover, blockchain companies potentially undermine existing laws, stifling the growth of emerging economy, whereas other books question the huge gains by venture capitalists, arguing the susceptibility of sharing economy to both monopolization and conspiracy (Sun et al., 2020c). However, some researchers state the importance of companies, not recognizing them as participants in the sharing economy; the workers are thus predicted to be presented with similar employment and working in countries with a high per capita GDP. This process tackles the issues of rising inequality, showing the potential to do away with the questions of whether the shared economy is helping to promote sustainable economic growth (Tothmihaly et al., 2019).

In this context, the study presents findings from literature for different indicators, such as digitalization, new economic models, and consumer awareness affecting SDG 7 under energy efficiency vision 2050. Hence, the role of such indicators on SDG 7 achieves significant focus by theorists and practitioners, whereas the role of consumer awareness, digitalization, and new economic models has different effects on SDG 7, crucially halting the acquisition of energy efficiency vision 2050. Therefore, such effects suggest different aims, including the following:

(i) To estimate long-run scenarios of digitalization, consumer awareness, and new economic models until energy efficiency is achieved in 2050
(ii) To achieve comparatively active and prudent utilization of renewable energy sources
(iii) To explain multiple time bound conditions associated with SDG 7 about energy efficiency vision, linking it with technological settings, energy sectors, and carbon emission factors under the procedures of European Commission (2010a, 2010b)
(iv) To locate and empirically estimate the long-run trends of new economic models, energy awareness, and digitalization, developing competitiveness for energy-efficient systems in the context of this study
(v) To measure the objective of specific policies associated with energy efficiency vision and SDG 7 to maximize the national economic growth by applying viable policy measures

Moreover, the recent techniques used in research include both qualitative and quantitative approaches. Qualitative approaches inside this context include literature reviews (IEO/EEC, 2017), stakeholder interviews as well as trials (CALCES, 2018), and expert polls (EC, 2018b), whereas quantitative methods frequently involve mathematical analysis, interconnected assessment, modelling, and cost comparison.

Similarly, Table 1 shows elements relevant to the latest cultural developments and alternative technology and the shortlisted social developments in this paper reveal the capacity to lower energy demand substantially and rise sharply if unproductive trends unfold, without guiding policies and decreasing energy demand at the center or without consumer awareness (Copiello, 2016). Although the literature review shows new socioeconomic patterns occur, many facets of the study of their impact on energy use remain underappreciated. Therefore, it is difficult to estimate potential energy needs until trends appear on the market. Furthermore, this section shows a rough quantification of the impacts of energy demand, excluding the considered patterns, such as digitalization—IEA/

Table 1 Measurement proxies of the variables

Variable	Dimension
Industrial change	• Reindustrialization • Circular economy—new requirements for material flows for consumer goods • Decarbonization of the industry
New economic models	• Distributive economy • Prosumer awareness (of personal carbon footprint) • Social disparities/energy poverty new forms of funding • Public spending towards greener
Quality of life	• Growing significance of health (e.g., air quality, noise, heat) • Regionalization—urban governance solving global challenges nearby in towns • Urbanization—worldwide tendency towards greater parts of the people alive in cities
Energy digitalization	• Human–machine/change to smart goods and facilities

OECD, 2017. Hence, the challenges noted previously include the consistent lack of baseline expectation and the need for a feasible way to consider double-counting mechanisms for model-based analyses. Therefore, the following hypotheses are developed in light of the literature cited above:

H1: There is a significant role of economic models on energy efficiency in OECD countries to achieve energy efficiency vision 2050.
H2: There is a significant role of mass digitization on energy efficiency in OECD countries to achieve energy efficiency vision 2050.

Data and research framework

This segment presents the framework for identifying and quantifying emerging social. In the process of figuring out the long-out, a 2050 energy model was executed between January and September 2018, with the assistance of 3 workshops of 20–30 specialist Europeans in energy, environment, and industrial sector. In this context, specialists and experts included members of several various industries, including environmentalists from Europe. Hence, this research was done in four distinct steps: identify trends, understand them in depth, enlist experts, and create scenarios and use those scenarios to run a model analysis, as shown in Table 1.

Following that, the developed scenarios are described and the first three steps are based on identifying social developments that would significantly affect the realization of energy sustainability and their capacity to cause an increase or decrease in energy demand. Similarly, Step 4 looked at the effects of digitalization, new economic models, and energy consumer awareness movements on the individual models (Sheng et al., 2021). Hence, step 1 is about trend identification and such identification uses detailed policy notes requiring super large trends (D. Zhang et al., 2021, Hsu et al., 2021, and Ehsanullah et al., 2021). Thus, digitalization, energy consumer awareness, and new economic models are designated in relation to economic and social importance with various unsetting impacts on sustainable developmental goal number-7. Moreover, these effects on sustainable developmental goal number-7 are consistent depending on the temporal and societal conditions from the present till 2030, expected to be validated as suggesting implication beyond the financial year of 2030. Therefore, social and technological factors could be increasingly relevant between now and 2050 (but there is no way to know for sure). Consequently, it is assessed whether it pertains to the research and development as a pattern itself or certain facets of it (D. Zhang et al., 2021).

Quantile regression is usually regarded as the optimal technique for deciphering complex predictor-response relationships. Its greatest promise is in quantifying if and how predictor effects vary across response quantile levels. However, this potential has not been completely realized due to a lack of reliable, combined analysis methodologies for all quantile levels.

Furthermore, the amount of creativity attached to a social phenomenon within the science and invention environment by researchers and creators is overlooked, finding societal developments and 36 megatrends during this process. These pattern profiles are made with regard to big shifts in the form of megatrends, such as urbanization, people becoming older, a longer life span, and with a heavy impact, including digitization. Hence, this list of 60 broad patterns is considered on the energy system and the following 28 social patterns were also in reference to the energy system and are included in the ensuing process (Xu et al., 2020). However, recent study draws following empirical model for energy efficiency under energy efficiency vision 2050, where *f* stands for function, NEM indicates new economic model, ECA measures energy consumer awareness, and MAD indicates mass digitalization with *i* intersections along with *t* time period (W. Li et al., 2021a, b, Chien et al., 2021, and Iqbal et al., 2021).

$$EE = f\left(NEM, ECA, MAD_{i,t}\right) \quad (1)$$

Moreover, the study model is estimated by using the following empirical equation, where EE indicates the energy efficiency, NEM indicates the new economic models, MAD shows mass digitalization, ECA indicates energy conservation, and ε_{it} shows the margin of error in regression equation at *t* time period.

$$EE = \beta_0 + \beta_1 NEM_{it} + \beta_2 MAD_{it} + \beta_3 ECA_{it} + v_i + \varepsilon_{it} \quad (2)$$

Using the fixed effect of panel quantile regression (PQR) model studied in the equation, it is converted as,

$$QY_{it}\left({}^{T}/_{X_{it}}\right) = \gamma(T)X_{it} + a_i i = 1, \ldots\ldots\ldots\ldots, N, t = 1, \ldots\ldots\ldots\ldots, T \quad (3)$$

Thus, the success model of the study is converted and drawn as,

$$QY_{it}\left({}^{T}/_{X_{it}}\right) = \gamma 1_T L_{it} + \gamma 2_T M_{it} + \gamma 3_T NEM_{it} + \gamma 4_T MAD_{it} + \gamma 5_T ECA_{it} \gamma 6_T T_{it} + a_i \quad (4)$$

Therefore, the coefficient function is estimated to assess the role of new economic models, energy consumer awareness, and mass digitalization, respectively, and the DEA method is applied to estimate the study findings. Moreover, the DEA (Mahlberg & Obersteiner, 2012) method is a non-parametric mathematical approach used to evaluate a range of comparisons. Similarly, decision-making units are represented as DMU. Hence, we use the CCR model (D. Zhang et al., 2021) as the primary model to evaluate the energy of total factor and energy efficiency under SDG 7. Let us suppose there are DMUs, marked with DMUj ($j = 1, \ldots, N$), each of them representing an administrative region of these 25 countries, where each DMU uses *m* non-energy input (labor, energy consumption, CO_2 per capita), X_{ij} ($i = 1, 2, \ldots, M$), and L energy input (labor, energy consumption, CO_2 per capita elj ($l = 1, \ldots, L$) to generate favorable *s*. Similarly, the output of Y_{rj} ($r = 1, \ldots, s$) represents the output of *K* unwanted or bad output ($k = 1, \ldots, K$). Therefore, in the manufacturing process, a DMU produces desirable products as much as possible, consuming input (labor, energy consumption, CO_2 per capita) resources as little as possible (Azadeh et al., 2007), whereas the energy sources, such as coal or oil used in these 25 countries, are virtually unalterable and the burning of energy generally generates waste gases, such as CO_2 and SO_2, which should be considered. Therefore, the measure of total energy factor and environmental efficiency reduces the consumption of energy for a given desirable product and non-input (labor, energy consumption, CO_2 per capita energy, and CO_2 more desirable) (W. Li et al., 2021a, b). However, it is not allowed to reduce contaminants in standard DEA models, which is addressed by a number of methods, such as using rewards of unpleasant outcomes, treating unwanted outcomes output as input (labor, energy consumption, CO_2 per capita), and mathematically translated unwanted outputs into favorable outputs under classification. In our study of energy and environmental efficiency, unfavorable results were mainly generated by fossils and the fuel burned during the manufacturing process should be reduced if energy consumption is reduced. Therefore, similar to Liu et al. (2013), we first present the following DEA-based radial model to measure the sum and extent of environmental energy efficiency as,

$E_1 = min\theta$

s.t

$$\sum_{j=1}^{n} \lambda_j X_{ij} + S_i^{x-} = X_{ij0}, \quad i = 1, \ldots, m, \tag{5}$$

$$\sum_{j=1}^{n} \lambda_j X_{ij} + S_i^{x-} = X_{ij0}, i = 1, \ldots, m, \tag{6}$$

$$\sum_{j=1}^{n} \lambda_j e_{lj} + S_l^{e-} = \theta e_{lj0}, l = 1, \ldots, L, \tag{7}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} + S_r^{y+} = y_{rj0}, r = 1, \ldots, S, \tag{8}$$

$$\sum_{j=1}^{n} \lambda_j b_{kj} = \theta b_{kj0}, k = 1, \ldots, K, \tag{9}$$

$$\lambda_j, S_i^{x-}, S_l^{e-}, S_r^{y+} \geq 0, forallj, I, l, \tag{10}$$

Since model (5) produces undesirable outputs proportional to the energy input (labor, energy consumption, CO_2 per capita as much as possible for a given level of non-energy input (labor, energy consumption, CO_2 per capita as and favorable outputs. Similarly, model (6) shows energy efficiency index θ for a region between 0 and 1 and the larger the index, the better the ability of the corresponding region to save energy and reduce pollutant release. Consequently, if $E1 = 1$ ($\theta = 1$) and all slacks S_i^{x-}, S_l^{e-}, S_r^{y+} are zero, the corresponding region is considered energy-efficient and environmentally friendly, and does not reduce energy consumption and pollutant release (Briec & Horvath, 2009). If $E1 < 1$ ($\theta < 1$), and (or) some of the slacks are not zero, then the corresponding region is energy and environment ineffective, and has the potential to reduce energy use and pollutant release. Therefore, the total factor energy and environmental efficiency measure shown by the model is a type of radial efficiency with a potentially poor discriminatory power in the relative energy efficiency. Therefore, we extend the radial energy measure to a non-radial count measure as,

$$E_2 = min\frac{1}{2}\left(\frac{1}{L}\sum_{l=1}^{L}\theta_l^e + \frac{1}{K}\sum_{k=1}^{K}\theta_k^b\right)$$

s.t

$$\sum_{j=1}^{n} \lambda_j X_{ij} + S_i^{x-} = X_{ij0}, i = 1, \ldots, m, \tag{11}$$

$$\sum_{j=1}^{n} \lambda_j e_{lj} + S_l^{e-} = \theta_l^e e_{lj0}, l = 1 \ldots\ldots L, \tag{12}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - S_r^{y+} = y_{rj0}, r = 1, \ldots, S, \tag{13}$$

$$\sum_{j=1}^{n} \lambda_j b_{kj} = \theta_k^b b_{kj0}, k = 1 \ldots\ldots K, \tag{14}$$

$$\lambda_j, S_i^{x-}, S_l^{e-}, S_r^{y+} \geq 0, forallJ, I, l, \tag{15}$$

Furthermore, model (8) measures energy efficiency (E_2) through various disproportionate configurations for different energy inputs (labor, energy consumption, CO_2 per capita as pollutant outputs, which account for the effects of energy) (θ_l^e) and effects of pollutant output (θ_k^b), respectively. Therefore, model (11) allows energy consumption and pollutant emissions to be reduced differently. Proportions to allow the analyzed these selected countries to reach their best point of energy and environmental efficiency. Boundary. Hence, it is important to notice how, in model (2), energy efficiency and environmental efficiency are evaluated using various non-proportional adjustments and a specified decision maker calculates the unified efficiency considering the weights assigned to each of these two efficiency scores. However, the manufacturer can also assign different weights to show different energy use performance preferences or environmental protection performance in a unified efficiency equation. Hence, in model (12), only when $\theta_l^e = 1$ and $\theta_k^b = 1$ for all l and k (i.e., $E2 = 1$), all slacks are zero in the corresponding energy-efficient and environmentally friendly region (Abu Bakar et al., 2019). In this context, model (12) has a higher discriminatory power than model (1), so we will use model (12) to evaluate the total-factor energy and environmental efficiency under SDG 7.

Results and discussion

Energy efficiency

Recent research predicts an increase in renewable energy by 1% by 2030 to boost the GDP by 3.1% and productivity by 3.1% in OECD. Consequently, the expansion of renewable energy improves the economy and productivity of the industry, impacting the efficiency of the oil refining industry, which is validated by the existing research, and the more money spent on research and development (R&D), the more efficient the sector becomes. Similarly, the energy efficiency of OECD improves by 0.4305% if R&D spending rises by 1% (see Table 2). In this context, our ability to foresee the future results of new social developments is limited only by our understanding of what the experience tells us. Moreover, the three scenes show dramatic (non-linear) social-societal shifts potentially affected by energy efficiency strategies, suggesting reduced demand on the left side of the graph, which is left as it is. This design concept is based on 2016 PRIMES (2016, Primes reference scenario) estimates and the scenario provides a foundation for increasing energy use by drivers of demand. However, new developments and events are seen as an evolution rather than a sudden break from the past. Moreover, research on technological and nearly economic barriers to energy efficiency concentrates on realizing the close potentials in the market, suggesting the addition of new patterns, showing an almost invisible continuation of existing ones. Consequently, our findings are consistent with Sun et al. (2020d, 2020e, 2020f).

Table 2 Energy efficiency of OECD

Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Australia	0.59	0.25	0.37	0.33	0.55	0.84	0.85	0.66	0.41	0.66	0.40	0.41	0.47	0.44
Austria	0.82	0.38	0.71	0.32	0.75	0.53	0.55	0.96	0.87	0.55	0.65	0.76	0.62	0.76
Belgium	0.79	0.37	0.70	0.54	0.80	0.94	0.67	0.80	0.60	0.74	0.56	0.58	0.61	0.58
Canada	0.62	0.27	0.40	0.38	0.57	0.87	0.86	0.68	0.41	0.63	0.40	0.41	0.40	0.41
Czech Republic	0.67	0.28	0.53	0.38	0.58	0.87	0.80	0.70	0.47	0.67	0.44	0.45	0.44	0.48
Chile	0.74	0.36	0.58	0.49	0.72	0.96	0.79	0.70	0.43	0.64	0.41	0.42	0.41	0.42
Denmark	0.69	0.28	0.52	0.32	0.72	0.80	0.94	0.81	0.64	0.79	0.52	0.58	0.52	0.58
Finland	0.69	0.31	0.56	0.38	0.74	0.88	0.88	0.80	0.60	0.74	0.53	0.57	0.53	0.53
France	0.70	0.32	0.56	0.46	0.67	0.96	0.75	0.70	0.43	0.65	0.44	0.44	0.44	0.44
Germany	0.74	0.33	0.66	0.42	0.77	0.93	0.63	0.81	0.67	0.73	0.52	0.60	0.52	0.60
Greece	0.64	0.27	0.47	0.36	0.63	0.89	0.84	0.71	0.46	0.65	0.44	0.45	0.48	0.45
Hungary	0.73	0.33	0.61	0.40	0.78	0.93	0.80	0.79	0.62	0.73	0.55	0.59	0.58	0.59
Ireland	0.69	0.32	0.51	0.44	0.70	0.94	0.87	0.73	0.45	0.69	0.47	0.46	0.47	0.43
Israel	0.81	0.41	0.64	0.71	0.84	0.98	0.73	0.75	0.53	0.70	0.55	0.54	0.52	0.54
Italy	0.70	0.30	0.60	0.30	0.75	0.73	0.92	0.85	0.76	0.87	0.60	0.68	0.60	0.68
Japan	0.78	0.40	0.73	0.81	0.82	1.00	0.58	0.71	0.46	0.65	0.50	0.48	0.52	0.51
Korea	0.88	0.47	0.65	0.46	0.80	0.74	0.81	0.95	0.85	0.50	0.65	0.75	0.64	0.75
Mexico	0.73	0.33	0.61	0.43	0.73	0.93	0.81	0.75	0.53	0.70	0.49	0.51	0.49	0.51
Netherlands	0.74	0.36	0.55	0.45	0.87	0.95	0.94	0.78	0.55	0.71	0.54	0.55	0.54	0.55
New Zealand	0.87	0.54	0.77	0.52	0.96	0.91	0.90	0.92	0.81	0.85	0.81	0.81	0.81	0.81
Norway	0.74	0.34	0.45	0.66	0.74	0.91	0.79	0.69	0.44	0.67	0.48	0.45	0.48	0.45
Poland	0.77	0.40	0.55	0.45	0.95	0.94	0.83	0.88	0.77	0.78	0.71	0.74	0.71	0.74
Portugal	0.69	0.31	0.54	0.44	0.82	0.93	0.90	0.80	0.57	0.73	0.53	0.55	0.53	0.55
Slovak Republic	0.75	0.32	0.58	0.35	0.79	0.49	0.60	0.98	0.73	0.58	0.73	0.73	0.73	0.73
Spain	0.70	0.32	0.61	0.39	0.74	0.92	0.65	0.80	0.51	0.73	0.56	0.53	0.56	0.53
Sweden	0.78	0.37	0.61	0.56	0.89	0.97	0.76	0.81	0.60	0.73	0.57	0.58	0.57	0.54
Switzerland	0.67	0.30	0.51	0.35	0.71	0.90	0.84	0.76	0.56	0.72	0.48	0.52	0.50	0.55
Turkey	0.77	0.36	0.60	0.56	0.72	0.99	0.65	0.66	0.45	0.64	0.43	0.44	0.47	0.52
UK	0.83	0.44	0.65	0.60	0.74	0.99	0.80	0.78	0.55	0.67	0.52	0.53	0.54	0.57
USA	0.56	0.24	0.32	0.35	0.46	0.78	0.72	0.61	0.35	0.57	0.52	0.53	0.56	0.63

Austria shows the highest energy efficiency scores recorded at 0.76 and 0.75, whereas Canada and Chile show the lowest energy efficiency score at 0.41 and 0.42. Similarly, the energy efficiency of the OECD is expected to drop by 0.1551% if crude oil output rises by 1% and energy efficiency of decreased crude oil output grew in the OECD. Hence, countries producing resources are experiencing increased imports of industrial products as compared to increased resource exports. Moreover, OECD energy efficiency of the industry is decreased by 1.8697% with 1% increase in energy consumption, and the higher the amount of energy consumed, the more likely it is to generate clean energy. This subset includes the associated unique energy management options, primarily concerned with addressing each of the end-uses (see Fig. 1).

Therefore, both the stories are valid considering the elimination of market barriers. Furthermore, the economic and close-to-economic capacities for energy efficiency are fully realized, allowing the removal of market barriers, and many non-socially shared and powerful effects are seen in the latest developments, such as growing energy consumption with weak penetration of the shared and digital economy trends, unable to proceed straightforwardly or logically.

Scenario analysis

Step 2 elaborates bottomless dive analysis, which carries out an in-depth study, exploring social patterns pertaining to the energy environment. In this context, basic improvement metrics are established after presenting the energy conservation and energy demand impacts to experts and their opinions are highlighted in step 3. Consequently, the second expert workshop, the list of potential future energy demand patterns was reduced to include the 12 stated by the energy efficiency theory. Furthermore, the four major social, economic, and economic movements presented in Table 3 show digitalization of life, industrial transformation, new economic models, and industrial continuity.

However, the concept is now an iterative mechanism, relying on substantial participation from stakeholders and experts, which potentially continues to change in various endeavors, whereas step 4 elaborates two segments, scenario analysis and quantified questions from these scenarios. Hence, OECD countries provide 63% of global GDP. Similarly, the OECD countries show a similar footprint, producing approximately 85% of the global GDP. Therefore, rapid economic growth is the primary cause of excessive energy consumption, presenting significant environmental problems worldwide, and the global economy is projected to expand by almost 50% until 2050 due to the rapid pace of development in mobility and urbanization as shown in Table 4. Consequently, the

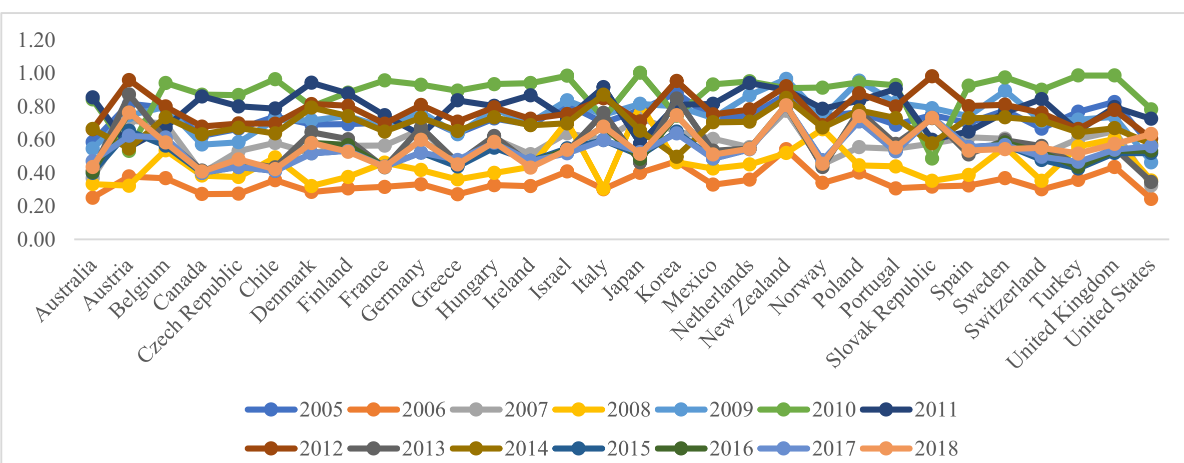


Fig. 1 Energy efficiency trend

Table 3 Tendency analysis of expert responses

Tendency	Reducing number of households	
Energy system relevancy		• Quicker uptake of new services • Minimum share of ownership • Impact on income and consumption pattern
Possible options	Boosting energy efficiency	• Upsurging energy efficiency with services and solutions • Upsurging energy efficiency through urbanization and less commuting
	Reducing energy efficiency	• Through appliances and living space per capita • If it leads to poverty
Applying indicators for conversion		• Ownership rates and lifetime of appliances • Square meters passenger-kilometer

successful implementation of environmental degradation regulations through renewable energy production activities, changing consumption habits, is critical.

Furthermore, the second portion of step 4 explains the distinct settings. Thus, the magnitude of the quantification provided in different studies is evaluated and the effect of detailed patterns on critical modelling parameters is identified showing both energy-increasing and energy-decreasing effects. (iii) Converting transition indicators into model parameters by calculating the unavailable parameters in the current literature. This measure is undertaken with caution to avoid overestimating the impact of emerging social changes on energy demand in the different scenarios. (iv) Finally, using the approximate criteria, the energy demand in the scenarios is scaled by sector and end-uses, and as we concentrate on the demand side of energy usage in these cases, the potentials significantly impact total inland use, including non-energy uses. Hence, gross possible inland usage is determined by material quality, conversion efficiency, and final energy-related efficiency steps. Similarly, gross inland demand savings are also strongly affected by the transition to a more competitive power production combination. Therefore, we use the European Commission's (2016a) report on energy mix for the benchmark situation, showing a power blend with a higher proportion of renewable energy sources to be used on the European Council (EUCO) 3030 example (see Table 5). Moreover, the identification of patterns incorporated into the benchmark growth, eliminating market barrier scenarios, is reviewed. Both examples already include a portion of the latest cultural patterns, and can be considered a continuation of the previous changes.*Estimating the role of new economic models, digitalization, and consumer awareness on SDG-7.*

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") along with the possible contributions of new societal trends towards the increase or decrease of energy demand in the EU until 2050 and thereby to its

Table 4 Producing energy mix through low carbon emission in South Asian countries

	RES	Biomass	Heating oil	Solids	Natural gas	Nuclear
2010	11%	2.5%	7%	17%	13%	31%
2020	24%	4.1%	4%	12%	9%	26%
2030	38%	7.3%	1%	5%	6%	14%
2040	44%	13.4%	1%	2%	3%	6%
2050	59%	19.2%	0%	0%	1%	2%

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 Scenario-wise analysis of study variables in South Asian countries

	Scenario 1 (worst case)	Scenario 2 (energy inefficient)	Scenario 3 (market barriers)	Scenario 4 (efficient systems)
Starting point	1191.45	1304.09	874.10	569.13
Energy consumption till 2050 in Mtoe (% change compared to "Baseline")	972.4 (−24%)	1049.6 (+35%)	677.4 (−41%)	217.16 (−84%)
Gross inland consumption in 2050 in Mtoe (% change compared to "Baseline")	614.6 (+23%)	702.4 (−38%)	444.7 (−53%)	305.11 (−13.4%)
Energy-related GHG emissions in 2050 in Mtoe (% change compared to "Baseline")	234.2 (+12%)	315.7 (−41%)	454.1 (−62%)	144.7 (−9%)

emission reduction targets. Hence, four possible scenarios are designed for the year 2050 with the help of top advisors, which represent the "baseline maps." Moreover, the techno-economic scenarios on the left-hand side of Fig. 2 show the policies producing the highest amount of energy efficiency with low efforts or producing high amounts of energy savings while using the least energy consumption. The OECD sample is chosen because OECD nations now account for roughly 63% of global GDP in US dollars, whereas fiscal decentralization seeks a large quantity of non-renewable energy to meet revenue targets in the face of weak environmental tax laws. Hence, the "race to the bottom" strategy in OECD countries gains credibility due to the pollution-intensive sectors with poor environmental standards, poor institutional quality, more open hand investment possibilities, and increasing usage of fossil fuels. Moreover, the OECD's carbon footprint observes a significant rise since 2000 due to the recent increases in transportation and energy consumption. Consequently, the majority of emissions in OECD countries is recorded by energy industries (29%), transportation (24%), manufacturing industries (13%), agricultural (9%), industrial processes (7%), and garbage (3%).

Removing energy market obstacles: scenario 1—techno-economic settings

The obstacles for economic performance are lowered, employing the energy first policies in an eliminating market barrier scenario (European Commission, 2016b), which assumes a constant forecast for economic development (sectoral GDP, population rise, and vehicle miles traveled). Therefore, both aspects of the economy benefit from more efficient use of resources due to greater creativity and technological capacity. Conversely referred to as the opportunities with consistent technological solutions and possible financial benefits or better energy performance with low additional funding and little or no payback. Hence, to estimate the investment cost and projected electricity price, various costs are calculated, including production costs and timing. However, but only the investment periods of technology, different techno-economic viability, and lifetimes and investment periods of the technology were included at the point of adoption, which introduces a decrease in primary energy demand and CO_2 intensity by the year 2050, as shown in Table 6.

Table 6 helps to gain a description of the procedure used to examine energy quality, whereas assets are valued by an economic strategy, not from the top down, using techno-economic potentials. Moreover, central to the ODESI projects includes technical and policy details for production and the national figures for the EU, integrated into the ODSI system (20EU), and our findings are aligned with Mohsin et al., (2018b, 2020, 2021).

First, the power is measured in the "PRIMES index" status of the European Commission (2016a), in which savings are adjusted taking into account has updated the last requirement for energy, job changes, and energy change in each sector. Second, power, acquired between 2009 and 2016, is being pulled more than ever identified strength. Thus, the downturn in some sectors is the result of a combination of diminishing and / or potentially already acquired jobs, while increasing power is traced back to higher work speculation. Third, in the actual Fraunhofer ISI

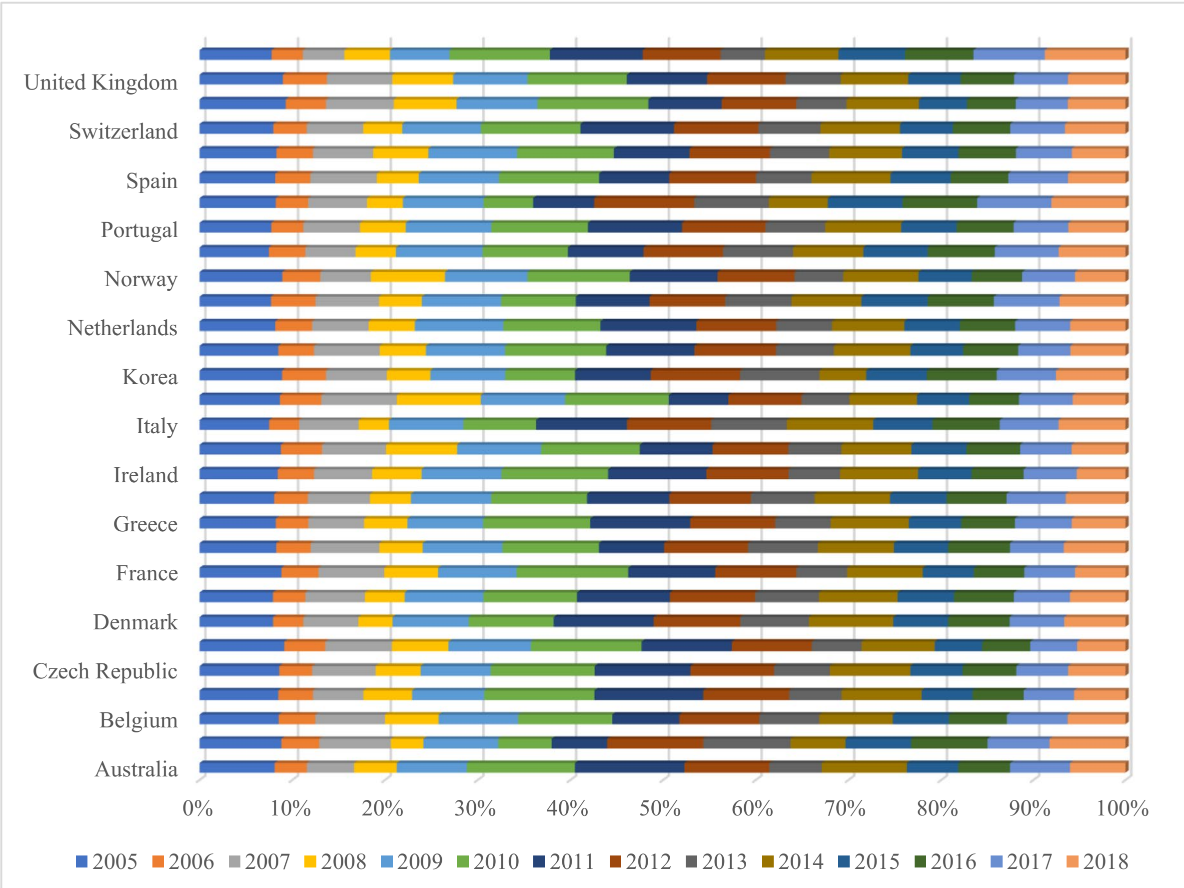


Fig. 2 Year-wise energy efficiency of OECD

Table 6 Scenario-wise role in SDG 7 from South Asian countries

	Scenario 1 (worst case)	Scenario 2 (energy inefficient)	Scenario 3 (market barriers)	Scenario 4 (efficient systems)
General energy consumers	127.7	88.5	44.0	21.9
Services	94.1	33.9	24.7	6.17
Industry	123.7	87.1	156.4	79.6
Transport	139.1	25.7	20.8	24.8
Total	444.5	24.8	13.6	17.0
Scenario-wise role on SDG 7 to support energy efficiency vision 2050				
Industrial change	11.8 (14%)	14.2 (16%)	1.9 (0.18%)	19.1 (41.6%)
New economic models	54.5 (29%)	17.2 (27%)	13.7 (2.67%)	29.4 (67.8%)
Quality of life	67.4 (14%)	33.8 (53%)	9.0 (34%)	15.12 (9.3%)
Energy digitalization	24.7 (48%)	7.5 (13%)	18.6 (45%)	24.6 (22.1%)

(2009) study, energy efficiency estimates are tested until 2030, extended until 2050. In this context, the identified energy saving is expensive, too. as technological power is almost less expensive than theater power (see Fraunhofer ISI, 2009; Fraunhofer, 2014 for more details).

Bringing focus to save energy by removing market-based obstacles

Following their commercial introduction in the mid-1980's, they were for sale in 1989, via special channels and stores for prices about 25 US$ + sales tax/VAT. Hence, they are presently sold in many countries in normal retail shops for prices in the range of 3–8 USD + sales tax/VAT, whereas the lower prices are for less-known brands with a standardized quality and the higher prices are for well-known brands and usually for bulbs with longer service life. Hence, the assumption of 25% inflation introduces an effective price reduction of 5–10 times, changing the economical balance in favor of fluorescent lamps in the large majority of applications in Western Europe and USA, which makes them economically favorable in many applications in countries with low electricity prices. Furthermore, global challenges, such as growth, urbanization, scarcity, and environmental change, become the key strategic drivers for business in the coming decade, presenting vast opportunities in a broad range of business segments with huge transformational capacity, according to energy efficiency vision 2050. Similarly, the broad order of magnitude of some of these is potentially around US$ 0.5–1.5 trillion per annum in 2020, with a rise between US$ 3 and 10 trillion per annum in 2050 at today's prices, which is around 1.5–4.5% of world GDP in 2050, considering the natural resources, such as health and education.

Energy efficiency and energy conservation opportunities

Renewable energy enables a significant improvement in the energy efficiency of OECD, decreasing the degree of pollution. Similarly, the increased use of renewables and the use of more efficient gas-fired power generation and a minor use of coal for electricity generation show an improvement in average power plant performance, increasing from 36 in 1990 to 44% in 2014.

Figure 2 shows the relationship between energy prices and "consumption reduction" of electricity and a dramatic increase in sulfur and nitrous oxide emissions in the power sector between 1990 and 2003. Similarly, sulfur dioxide emissions show a decrease by 77% between 2014 and 2015, whereas particulate emissions show an 81% decrease and a 45% decrease in nitrous oxide emissions. Moreover, market liberalization and energy sector reforms increase energy efficiency through privatization, wholesale competition, retail competition, spin-off, and autonomous regulation implementation. Since the 1990s, privatization, considering the invitation for independent power producers to build power plants, is observed in many countries of OECD. Despite the fact that it has been in the eighteenth century since the first independent energy purchase, only a few private companies have built power plants and supplied power to the national grid. Hence, the strong opposition from labor unions and civil society causes the power sector to remain state-owned and regulated.

Therefore, the following aspects should be considered while forming electricity and technical feasibility reforms.

(i) An impact of quality and security on energy efficiency
(ii) An availability of maintenance requirements and extras

The equipment efficiency is aided with the best technology, such as (i) transmission networks, which are highly dependent on power companies, (ii) the variation in investment costs, and (iii) the misery associated with the application of commission which helps in achieving important and drastic advantages, after forming a balance between energy consumption and quantity.

Sustainable economic development is accomplished in the long run, by associating the production and distribution of electricity from policymakers, as shown in Fig. 3, with public–private partnership as policy tools. Hence, the idea of decentralization of renewable resources forms the basis for a public and private partnership to generate electricity, which helps to achieve the desired outcomes for energy efficiency and electricity consumption. As shown in

Table 9, 72% of the developing economies possess a governing body up to 2015 due to the four main policy advices from the Washington consensus. However, it is significantly behind the 91% application of regulatory bodies among the developed countries.

Similarly, Tables 7 and 8 show the regional development and market structure. In this context, the coupling of the power flows between the Netherlands and France before and after the coupling prices increases to €14–15/MWh, 39% of the time. Hence, the difference between prices from less than €1.5/MWh and the gross energy trade volume is nearly € 16 billion p.a. Therefore, the importance of full business pairing corresponds to around one-quarter of this (€ 4 billion p.a.), whereas business pairing occupies 58–66% of the business, the total profits sum to € 2.5 billion p.a., and about €1.5 billion p.a. benefits can be achieved if all interconnectors in the EU are merged. Consequently, the countries in OECD region are now some of the most energy-intensive in the world, with the least energy-intensive in the region requiring 10% more energy than the global average to generate a dollar of economic output.

The electricity balance includes 50% solar energy and 25% for CCS in power production by the year 2030, which acts in a way that save energy are needed in order to save energy.

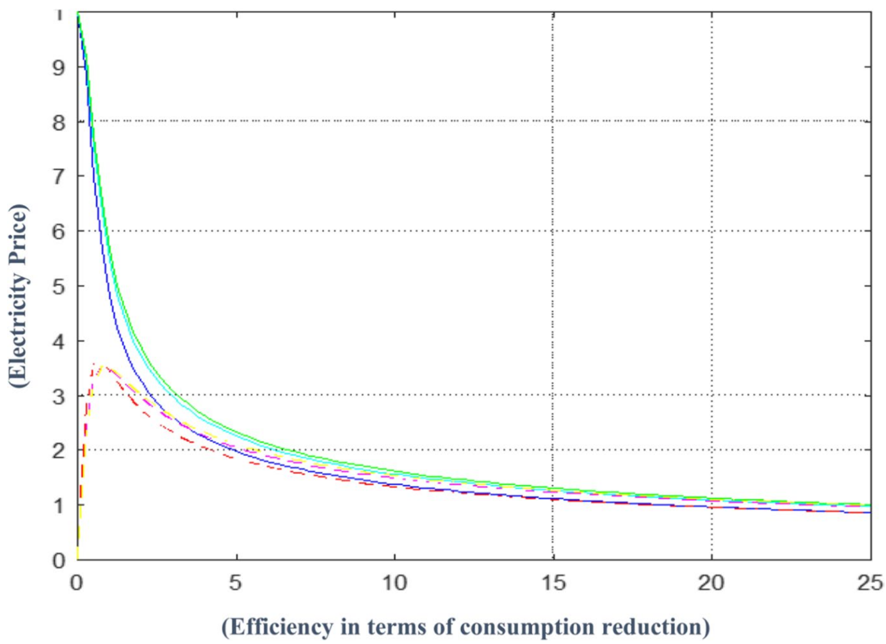


Fig. 3 Electricity price and consumption reduction

Table 7 Regional development

Regions	Connection rates (%)		T&D losses (%)		Electricity consumption p.c		Reform score	
	1982	2014	1990	2016	1990	2016	1982	2013
East Asia and Pacific	10	12	60	84	253	599	0	3.8
East. Europe and Central Asia	13	7	100	100	673	983	0	5.4
Latin America and Caribbean	17	15	78	94	306	707	0.2	4.5
The Middle East and North Africa	18	13	86	96	1280	2113	0.3	3.7
South Asia	18	22	30	91	40	210	0	3.9
Sub-Saharan Africa	20	13	17	42	75	154	0	3.3

Source: Dertinger and Hirth (2020)

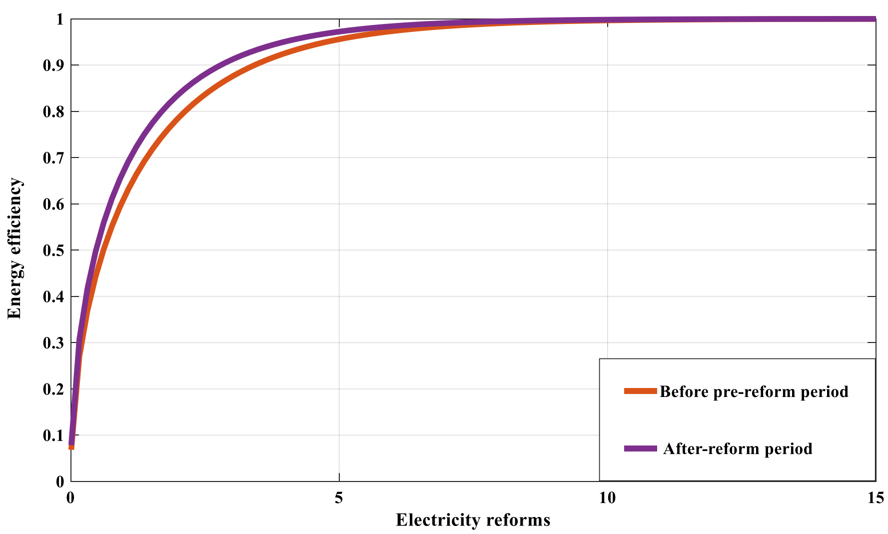
Table 8 Market structure

Feature	Monopoly	Single buyer	Wholesale competition	Retail competition
Competing generators	No	Yes	Yes	Yes
Choice for retailers	No	No	Yes	Yes
Choice for customers	No	No	No	Yes

Source: Hunt and Shuttleworth (1996)

1. COGS, the EU reference scenario ("PRIMES, 2005–2030"), reaches its height in 2005 and continues to fall until 2030 and is projected to rise over the subsequent months. Hence, between the years 2000 and 2050, the death rate is predicted to fall by 4%, and to realize this techno-economic potential, final energy demand will be decreased by 51% in the year 2050. Therefore, Fig. 4 suggests the supply from the tertiary sector at 22%, with industries supplying 7% and significant shifts to electric cars accounting for 13% of the rest. In this context, the tertiary sector accounts for agriculture as a portion of the total energy market, but is excluded from the primary and secondary sectors.
2. Hence, we need to keep gross inland consumption in check, and PRIMES 2016 indicates the gradual decrease in the final energy use, where non-energy final usage will continue to decline over time. Consequently, the targeted projection in the basic (or conservative) scenario expects a 15% decrease by the year 2050, whereas the contribution from the fuel-refining sector is marginal with no boost in conversion efficiency, such as oil products. This implies a net decrease of 60% in total usage through the 40% decrease in the on-to-land electricity demand.
3. GHG pollution mitigation is calculated during the evaluation of energy quality, and the emissions in the PRIMES 2016 emissions are predicted to fall by 43% by the year 2050, whereas electricity is already deriving the majority of its energy from low carbon sources and lower carbon-emitting energy. Moreover, the "emission loss attributed to conversions" is at a total of 21% in the year 2050 and 13.5% by including more hybrid cars to the fleet. Hence, the total energy conservation steps contribute to another 43% to the total pollution decrease as compared to earlier GHG emissions and the pollution rates are 78% lower as compared to 2010 and 81% lower from 1990. Consequently, these statistics only represent GHG emissions associated with energy use.

Fig. 4 Energy efficiency and reforms



Therefore, there is a need to save in the household sector as well and the baseline final energy demand is predicted to rise to a plateau by 2030, with just a slight addition of demand in the years after 2030. Similarly, another projection suggests an increase in the final energy consumption over the year 2025 and the year 2050. However, a 63% long-term saving potential is established, which results in a long-down effect in 2050 on overall energy consumption. Hence, more than half of these benefits occur due to the replacement of original casing, repairing the device in older houses, with a suggested 13% and 12% of the total saving which is realized by the design of new structures. Consequently, the reduced use of sanitary water, effective illumination, and low-energy appliances cause an increase due to the three contributions with 4% of the total savings.

Energy sector-based saving potentials: scenario 3

Furthermore, the social developments listed above are considered to be of significance for the energy use and parameters of tertiary and technological along with the technological and economic potentials being realized. Hence, the awareness of value potentially increases due to the increased need of building and appliance interconnection, pertaining to the market perception of changing levels of comfort and decentralized generation of electricity. Therefore, more people are now mindful of the effects housing and energy use have on the global climate, considering the urbanization results in reduced living spaces and an adaptation to the environment. In this context, the findings suggest the four pattern clusters will contribute to additional saving opportunities besides the sole techno-economic capacity of the "Removing Market Barriers" scenario. Hence, the final energy demand (FED) in the "New Trends Efficient" scenario is potentially Mtoe lower than the FED in the "Removing Market Barriers" scenario if all four pattern clusters unfold in a positive way. Moreover, the cluster of digitalization accounts for 22%, New Social and Economic Models cluster for 37%, and the cluster of Quality of Life for 41%. Consequently, the Industrial Transformation cluster would not have any new opportunities for private households.

Robustness analysis

Social developments have a significant effect on potential energy demand, as indicated by the results. Hence, Table 8 summarizes the key metrics of the various situations, and in the "Worst Case" scenario, a wide bandwidth of dramatically rising FED is observed, whereas substantial reductions within the techno-economic potentials are observed in the "New Trends Efficient" scenario. Furthermore, the findings of the "Fresh Trends Inefficient" scenario suggest new social developments due to direct and indirect rebound impacts, which significantly decrease energy savings. This goes to illustrate how new social movements are not necessarily good or bad for potential energy consumption, but the consequences will vary dramatically based on how they unfold, which is heavily influenced by accompanying policies along with other factors.

Table 9 shows the robustness analysis and most of the OECD countries are between 0.50 and 0.70, indicating an attempt to emulate advanced nations. This drop occurs as the external factors, such as the financial crisis in 2007–2009, show a direct impact on energy efficiency in OECD. Furthermore, environmental taxes help energy efficiency by reducing the per capita need for petroleum goods, promoting creative and technical goods, and stimulating development in clean energy sources. Therefore, environmental taxes receive a lot of attention in Europe and the OECD. Energy taxes, for example, account for 76.94% of all environmental taxes collected in Europe, accounting for about 2% of GDP and 5% of tax receipts on average. However, this exploratory work comes with some limitations. Firstly, the latest updates of energy efficiency goals and the accompanying policy framework, such as reviewed renewables directive, are not taken into account due to the rapidly developing European ambitions. Secondly, this analysis is based on previously identified cost-effective potentials. Although all potentials are updated considering structural changes, altered activities, and updated energy intensities, some haziness cannot fully be excluded.

Therefore, Table 8 summarizes the position of the four pattern sectors in FED removal outside their capacity for creating new markets. In this context, "Digital Life," "New Social and Economic Models," and "Quality of Life" contributed an estimated 28%,

Table 9 Sensitivity analysis

Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Australia	0.59	0.25	0.37	0.34	0.55	0.85	0.86	0.67	0.41	0.67	0.40	0.41	0.48	0.44
Austria	0.82	0.38	0.72	0.33	0.75	0.54	0.56	0.97	0.88	0.55	0.66	0.77	0.63	0.77
Belgium	0.80	0.37	0.70	0.54	0.80	0.95	0.68	0.81	0.61	0.74	0.57	0.59	0.62	0.59
Canada	0.63	0.28	0.40	0.39	0.58	0.88	0.87	0.69	0.42	0.64	0.40	0.41	0.40	0.41
Czech Republic	0.67	0.28	0.54	0.38	0.59	0.88	0.81	0.70	0.47	0.68	0.44	0.46	0.44	0.49
Chile	0.75	0.36	0.59	0.50	0.73	0.97	0.79	0.70	0.44	0.64	0.42	0.43	0.42	0.43
Denmark	0.70	0.29	0.52	0.32	0.72	0.81	0.95	0.82	0.65	0.80	0.52	0.59	0.52	0.59
Finland	0.70	0.31	0.57	0.38	0.75	0.89	0.89	0.81	0.61	0.75	0.54	0.57	0.54	0.53
France	0.71	0.32	0.57	0.47	0.68	0.97	0.75	0.70	0.44	0.65	0.44	0.44	0.44	0.44
Germany	0.75	0.34	0.67	0.42	0.77	0.94	0.63	0.82	0.68	0.74	0.53	0.60	0.53	0.60
Greece	0.64	0.27	0.47	0.36	0.64	0.90	0.84	0.72	0.47	0.66	0.44	0.46	0.48	0.46
Hungary	0.73	0.33	0.61	0.40	0.79	0.94	0.81	0.80	0.63	0.74	0.56	0.59	0.59	0.59
Ireland	0.70	0.32	0.52	0.44	0.71	0.95	0.88	0.73	0.46	0.69	0.48	0.47	0.48	0.44
Israel	0.82	0.41	0.64	0.72	0.84	0.99	0.73	0.76	0.53	0.71	0.55	0.54	0.52	0.54
Italy	0.71	0.30	0.61	0.31	0.76	0.74	0.92	0.86	0.77	0.88	0.60	0.69	0.60	0.69
Japan	0.79	0.40	0.74	0.82	0.82	1.01	0.58	0.72	0.47	0.66	0.51	0.49	0.53	0.52
Korea	0.89	0.47	0.66	0.47	0.81	0.75	0.82	0.96	0.86	0.50	0.65	0.75	0.64	0.75
Mexico	0.73	0.33	0.61	0.43	0.74	0.94	0.82	0.76	0.54	0.71	0.49	0.52	0.49	0.52
Netherlands	0.75	0.36	0.56	0.46	0.88	0.96	0.95	0.79	0.55	0.71	0.55	0.55	0.55	0.55
New Zealand	0.88	0.55	0.78	0.52	0.97	0.92	0.91	0.93	0.82	0.86	0.81	0.82	0.81	0.82
Norway	0.75	0.34	0.46	0.67	0.74	0.92	0.79	0.69	0.44	0.68	0.48	0.46	0.48	0.46
Poland	0.77	0.41	0.56	0.45	0.96	0.95	0.84	0.89	0.78	0.78	0.72	0.75	0.72	0.75
Portugal	0.70	0.31	0.55	0.44	0.83	0.94	0.91	0.81	0.58	0.74	0.54	0.56	0.54	0.56
Slovak Republic	0.76	0.32	0.58	0.36	0.80	0.49	0.61	0.99	0.74	0.58	0.74	0.74	0.74	0.74
Spain	0.71	0.33	0.62	0.39	0.75	0.93	0.66	0.81	0.52	0.74	0.56	0.54	0.56	0.54
Sweden	0.78	0.37	0.61	0.56	0.90	0.98	0.77	0.82	0.60	0.74	0.57	0.59	0.57	0.55
Switzerland	0.67	0.30	0.51	0.36	0.72	0.91	0.85	0.77	0.57	0.72	0.48	0.53	0.50	0.56
Turkey	0.78	0.36	0.61	0.56	0.73	1.00	0.66	0.67	0.45	0.65	0.43	0.44	0.47	0.52
UK	0.84	0.44	0.66	0.61	0.75	1.00	0.80	0.79	0.55	0.68	0.52	0.54	0.54	0.58
USA	0.57	0.25	0.33	0.36	0.47	0.79	0.73	0.61	0.35	0.58	0.52	0.54	0.57	0.64

35%, and 31%, respectively, to the decrease. However, “Industrial Transformation” contributes only 5% to the overall GDP growth of the nation. Similarly, the three prior clusters show a tendency to reduce the overall decline capacity in the utilities and transportation sectors compared to each other. Although the “Quality of Life” (41%) has a unique place in the household market, Digitalization of Life (22%) plays a comparable part, but its position of strength is decreasing in comparison to the rest of the FED (28%). This impact is closely tied to “New Social and Economic Models” and “Industrial Transformation” (19%).

Conclusion and implications

The improvement of efficiency is a critical factor in realizing the EU climate targets. Hence, the current study used the data envelopment analysis and scenario analysis of energy efficiency vision 2050 to realize the enhancement in projected energy efficiency gains based on SDG7 for OECD countries. Consequently, Austria shows the highest energy efficiency score at 0.76 and 0.75, whereas Canada and Chile show the lowest energy efficiency score at 0.41 and 0.42. This increase in productivity does not mean that there is a decrease in energy consumption. Hence, attempts to reduce the need for electricity, unfortunately, create an ever-growing need for it in both private and public sectors (IEA, 2019).

Numerous factors, comprising output costs and timing, are analyzed to determine the investment cost and anticipated energy price. Furthermore, although just the investment periods of technology were included, various technologies' financial impact, lives, and investing durations have only been used at the moment of acceptance, resulting in a reduction in electricity usage. During 2014 and 2015, while particle pollutants decreased by 81% and n2o pollutants decreased by 45%. Additionally, market liberalization and electricity policies improve energy efficiency in OECD nations via privatization, wholesale competition, retail competition, spin-offs, and adoption of independent regulations.

Similarly, data centers should increase to accommodate the increased storage capacity and this paper sets out to open up a dialogue on the subject of future changes in energy demand. Moreover, it forecasted four different demand patterns for the following year ("Base," "Market," "Trends," and "Crisis") with the possibility of new social patterns emerging to guide both individuals and policies, which help realize energy savings and spur technical innovation at the same time. Hence, the introduction of new social developments could contribute to an increase in energy inefficiency and climate neutrality. Among other steps, the EU suggested the EU1 as a fundamental factor in government policies, plans, strategies, and investments for the industry, whereas the environmental equality theory has already taken center stage in European energy and climate policy (European Climate Foundation, 2016). In simple terms, expenditure in customers such as end-use and supply-side energy efficiency and demand response should be factored into the model. Although energy efficiency is elevated to the status of a resource equivalent of generation and use in the energy efficiency strategy, numerous barriers still inhibit its integration and impact the benefits of the energy efficiency at the policy and business levels.

Therefore, the findings of this study indicate the direction of final energy demand in the years to come as considerably less predictable relying on various sociocultural phenomena, whereas new practices growing out of a particular pattern may either add to, or take away, from the overall energy performance. For instance, increasing energy use might not be followed by energy efficiency policies. Although this paper seeks to increase understanding of the broad energy developments, it is important to examine not just their possible benefits, but also their associated costs to truly measure their potential impact so the European policymakers could someday have a better understanding of the impact their strategies have on both energy consumption and productivity improvements if this experiment succeeds.

Similarly, market growth requires active participation of governments as a consumer, information supplier, and policymaker to encourage financing for energy efficiency. Therefore, specific energy efficiency financing windows in suitable financial institutions, such as banks, are required to grow the local financing market and it is also necessary to acquire skills in energy efficiency project assessment and the creation of finance products to carry out energy efficiency projects. Consequently, specialized energy funds and guarantee funds may be required in certain instances to jumpstart investment in energy efficiency initiatives.

Declarations

Conflict of interest The authors declare no competing interests.

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