Energy efficiency Trends and Policies in Switzerland (2000-2019/2020)

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Abstract

Improvement in traditional energy intensity indicator (2.8% p.a.) for Switzerland in the period 2000 to 2019 points to some decoupling of economic growth and energy demand. Since the improved energy intensity could be primarily driven by soaring value added, it is necessary to analyse 1) physical energy efficiency (EE) representing the contribution of technical progress to EE improvement and 2) the influence of other drivers of total final energy (TFE) demand. This work evaluates physical energy efficiency (EE) trends in Switzerland at various aggregation levels by applying the ODYSSEE energy efficiency index (ODEX). The ODEX methodology facilitates the estimation of physical (technical) EE trends based on subsector-specific physical activity indicators. At the time of preparing this report, data for 2020 were available for all sectors except for transport. The analysis therefore covers the period 2000 to 2019 both for transport and for the total economy whereas the temporal scope is otherwise the period 2000-2020. Switzerland improved its physical EE by 1.7% p.a. in the period 2000-2019. Physical EE improvement was partly enhanced by structural change but it was partly offset by larger dwellings, more appliances per dwelling and physical activity growth. The findings on energy efficiency improvement are put into the context of the policy measures implemented at the national level. The ODYSSEE-MURE scoreboard presents two indicators on energy efficiency improvement (level and trend) as well as an indicator on the effectiveness of the implemented policies. The combined indicator aggregating these three indicators identifies Switzerland as the best amongst all countries included in the ODYSSEE-MURE Horizon 2020 project. However, further work would be required to compare the achievements with the policy targets, to improve the indicator on the EE level and to consider the further course of policy making after the rejection of a newly proposed CO_2 law by the Swiss electorate in a public referendum.

Keywords: energy efficiency; decomposition analysis; energy efficiency trends; policy

List of abbreviations

BAU: Business As Usual
CC: Climatic Corrections
Dw: Dwellings
EE: Energy Efficiency
EED: Energy Efficiency Directive
ES2050: Energy Strategy 2050
ETS: Emission Trading System
FSO: Federal Statistical Office **FSOM**: First Set of Measures
GDP: Gross Domestic Product
GHG: Green-House Gas
Gtkm: Gross Tonne Kilometer
L: Level of energy intensity (or UC)
LMDI: Log Mean Divisia Index
NACE: European Classification of Economic Activities

NOGA: General Classification of Economic Activities in Switzerland
NEP: New Energy Policy
ODEX: Odyssee Energy Efficiency Index
PPP: Purchase power parity
Pkm: Passenger Kilometer
SEC: Specific Energy Consumption
SFOE: Swiss Federal Office of Energy
T: Trend of EE improvement
TFE: Total Final Energy
Tkm: Tonne Kilometer
UC: Unit Consumption
Vkm: Vehicle Kilometer

1   Introduction

1.1   Background

Growing concerns about climate change, other environmental impacts and security of supply as well as economic considerations have been the main drivers for industrialised countries to curb their CO_2 emissions and to reduce the dependence on oil and gas [1-7]. Improving energy efficiency (EE) can help the countries achieve multiple objectives such as lowering the energy bill, reducing energy dependence, decreasing greenhouse gas (GHG) and non-GHG emission while maintaining or increasing the level of economic activity as well as improving overall sustainability, e.g. by raising the share of renewable energy [8]. EE targets provide a basis for national governments to establish policies, programs and mechanisms directed toward improved EE [9]. As part of the Swiss Energy Strategy 2050 (ES2050), Switzerland adopted indicative targets according to which per person TFE demand should be reduced by 16% until 2020 and by 43% until 2035 as compared to the base year 2000 (or by 32% in 2035 compared to 2020). These values are based on the publication "Energy perspectives for Switzerland until 2050" which was released in 2012 [11, 12]. A new study called "Energy perspectives 2050+" has partially been published [59], with further elements to be released in 2022. According to the default scenario "Zero Basis" of the new study [59] total per-capita TFE decreases at a comparable pace as in the previous study, i.e. by 20% from until 2020 and by 41% until 2035, both relative to year 2000. Furthermore TFE in absolute terms (i.e., not per capita) is expected to decrease by 15% from 2020 to 2035 and by another 15 percent points from 2035 until 2050 according to the new study (see *Figure 1*). For the period from 2020 until 2035, the largest savings are anticipated for the service sector, followed by both industry and transport. In terms of end use, the most significant savings until 2035 are expected for space heat followed by mobility (*Figure 1*).
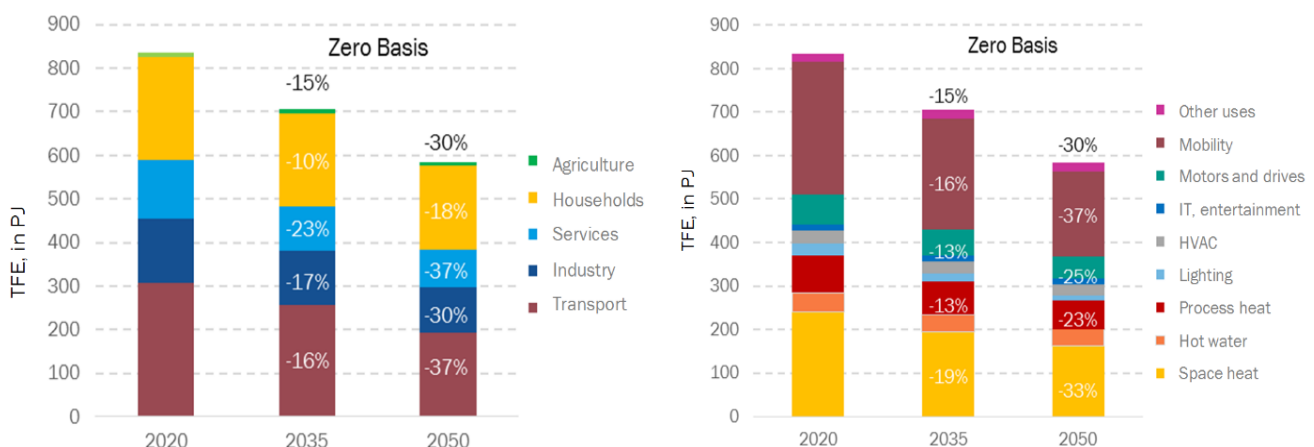

Figure 1 TFE per capita and data on boundary conditions according to the Zero Basis scenario of the Energy Perspectives 2020+ [59]

1.2 Methods applied to measure Energy Efficiency Trends

EE indicators allow to monitor the impact of EE policies (usually packages of policies) and they serve as basis for improved design of EE policies in order to achieve national targets [13]. To this end, EE indicators should be reliable (based on credible, available and comparable data), feasible (data cost, widely acceptable and respecting data confidentiality) and verifiable (data monitoring and feedback) [14]. There is a substantial body of international literature on the development, assessment and comparison of EE indicators [13-22], providing a framework for cross-country comparison of EE trends [2, 3], decomposition analysis to support policy design [23, 24] as well as for benchmarking across countries, sectors and subsectors [25-32]. Traditionally, monetary EE indicators that relate energy use to economic output (e.g. GDP, value added) are used to track the EE performance at the higher level of aggregation (e.g. entire economy) [12, 33]. Physical indicators relating the total energy consumed to the physical activity (e.g. tonnes of steel, passenger-kilometres) are generally considered as more closely linked to actual energy efficiency improvement than monetary EE indicators which are impacted by additional effects such as changes in the value of products, exchange rates, inflation and other factors. [1]. While hence being the preferred choice, physical indicators are typically used to track the EE performance at disaggregated levels such as a sector (e.g., residential sector, industry, transport, services) or – more frequently - subsectors (e.g., steel production, space heating, passenger transport etc.) [18]. Creating physical EE indicators for complex sectors with a large number of very diverse products (e.g. food or chemical sector) is not straightforward. The ODYSSEE EE index (ODEX) developed in the context of the ODYSSEE-MURE project (which covers EU28, Norway, Switzerland and Serbia) offers a number of advantages compared to the previous methodologies by allowing to establish EE trends at the higher levels of aggregation (i.e. complete economy or sector) based on subsector specific physical EE indicators and by comparing the trend and level of EE improvement across countries while respecting the sectoral heterogeneity [34] (see section 2.2 for detailed explanation).

1.3 Structure of economy and energy demand in Switzerland

As a result of a large service sector and high value added products in manufacturing, the GDP per person (at Purchasing Power Parity, PPP) is particularly high, placing Switzerland among the most productive countries included in the ODYSSEE database [35]. The Swiss service sector generates nearly 70% of country's total GDP while consuming 18% of TFE [35, 36]. The industry sector is responsible for 25% GDP generated by the Swiss economy [35] while consuming 19% of TFE (*Figure 2*). Agriculture contributed less than 1% of Switzerland's GDP. The shares of the transport and household sectors in TFE demand remained approximately at 33% and 29% respectively [37]. The majority of total primary energy demand of Switzerland is covered by oil products
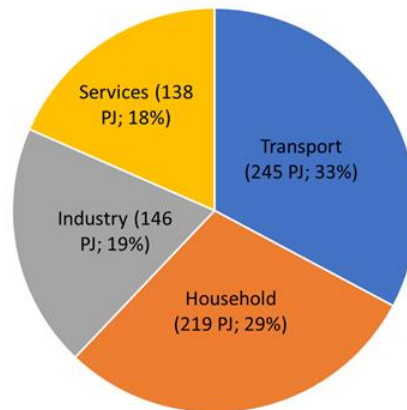
Figure 2 Share of sectors in TFE demand of Switzerland in 2020 [37]

1.4   Energy Efficiency Policy in Switzerland

The energy article in Swiss energy legislation puts an obligation on the federal government and cantons to ensure an adequate, secure, economic and ecological energy supply and economical and efficient use of energy [40]. The Swiss Energy Strategy 2050 (ES2050) is structured into a so-called "First set of measures" (FSOM, partly implemented to date) which is foreseen to be complemented by a second package (New Energy Policy, NEP). Both packages aim to improve EE and to promote the development of renewable energy, thereby allowing to substantially reduce CO_2 emissions while phasing out nuclear energy [41]. Furthermore, specific directives and policy actions exist for subsectors. For example, an Energy Efficiency Directive (EnV 730.01, 1998R) was implemented which specifies both energy performance for buildings and energy labelling for appliances (in line with EU legislation) [42]. For a number of household appliances, Swiss minimum energy performance standards are stricter than in the EU, making Switzerland a forerunner in this domain [43]. Within the industry sector, large energy consuming and greenhouse gas (GHG) intensive companies in Swiss industry sector are obliged to participate in the Swiss emission trading scheme (ETS) which was introduced in 2008 along with the CO_2 levy in order to curb GHG emissions [44]. Larger companies which are not regulated by ETS can enter into an agreement with the Federal office, the canton or third-party government mandated agencies (e.g. EnAW, act) to commit themselves to reduce GHG emissions, allowing them to get exempted from the CO_2 levy [45] and to obtain full or partial refund of the renewable energy network surcharge (KEV) [46]. A distance-related heavy vehicle fee is levied upon vehicles exceeding a maximum weight limit of 3.5 tonnes. As in the EU, CO_2 emission standards have been implemented in Switzerland for passenger cars to regulate the maximum level of CO_2 emissions per kilometre travelled [45].

1.5 Aims and objectives

In order to obtain a first understanding of the efficacy of current policy measures and the progress made towards target achievement, the nature and structure of energy use by sector need to be analysed as well as the underlying drivers and barriers. Against this background, the objectives of the current study are:

1. *To estimate the evolution of EE* in Switzerland at different levels of aggregation (i.e. Switzerland as whole, individual sectors and subsectors) and to make comparisons to the targets set by Swiss energy policy.

2. To *understand the factors driving the changes* in TFE demand of Swiss economic sectors by performing a decomposition analysis.

3. To *compare the EE trends and levels* of Switzerland by individual sectors with EU countries (at sector level).

This study further aims to provide better insight into the status and evolution of EE by comparing the EE trend of subsectors based on different activity indicators. The remainder of this paper is organised as follows. Section 2 describes the methodology adopted for the analysis of EE, decomposition analysis, cross-country comparison and benchmarking. Section 3 presents the results of EE trends analysis and decomposition analysis accompanied by a discussion about the comparison of Switzerland with other countries in ODYSSEE database (i.e. the position of Switzerland amongst countries included in ODYSSEE database) based on the level and the trend of EE improvement followed by the comparison of EE trends based on different activity indicators and comparison of current EE trend against the targets established by ES2050. Section 4 concludes.

2 Methodology

2.1 Data sources

To analyse the EE trends, a large dataset has been compiled consisting of macro-economic data (for tracking the development of the complete economy) to energy demand and activity levels of individual sectors (households, service, transport and industry; see Appendix A). The data required for estimating the subsectoral EE indices originates from publicly available national statistics and confidential data sources in some cases. The data required for cross-country comparison originates from the ODYSSEE-MURE database [35].

2.2 Odyssee energy efficiency index (ODEX)

In this study, we use the so-called ODEX, an index developed by the ODYSSEE-MURE project [34], to measure the physical EE progress by sector and for the whole country. The ODEX at the level of the national economy (Global ODEX) is an aggregation of physical EE trends (ODEXs) of the economic sectors (industry and services)

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as well as households and transport sectors based on their share in TFE demand (eq. 3). The EE trends for an individual sector is estimated by aggregating the EE trends of the subsectors/end-uses weighted by their respective shares in TFE demand (eq.1 and 2) (except for services; see section 2.2.4). For the subsectors, end uses or transport modes, the EE is tracked with the unit energy consumption index (UC; for details see sections 2.2.1 through 2.2.4).

$$I_{i,t-1}/I_{i,t} = \sum_j \left(\frac{UC_{j,t}}{UC_{j,t-1}} \times ES_{j,t} \right) \tag{1}$$

Where

$I_{i,t-1}/I_{i,t}$ = An aggregate index of sector i for the UC variation between the years t-1 and t

$UC_{j,t}$ = Unit Consumption index of subsector or end-use j for the year t (e.g. GJ/tonne product, GJ/pkm, GJ/m^2).

$UC_{j,t-1}$ = Unit Consumption index of subsector or end use j for the previous year t-1 (e.g. GJ/tonne product, GJ/pkm, GJ/m^2).

$ES_{j,t}$ = Final Energy demand Share of subsector, end use or transport mode j for year t

In order to harmonize the scale across all sectors, the ODEX of the first year is set to 100. For each subsequent year, the ODEX for the previous year is multiplied by the reciprocal of eq. 1 (see eq. 2) (the ODEX value hence decreases with improving EE).

$$ODEX_{i,t} = s \times \left(I_{i,t}/I_{i,t-1} \right) \text{ with } \quad s = \begin{cases} 100, & t = t_0 \\ ODEX_{t-1}, & t > t_0 \end{cases} \tag{2}$$

Where

S = Scaling factor

$ODEX_{i,t}$ = ODYSSEE energy efficiency index of sector i for the year t

$ODEX_{i,t-1}$ = ODYSSEE energy efficiency index of sector i for the year t-1

$$ODEX_{global,t} = \sum_y ODEX_{i,t} \times ES_{i,t} \tag{3}$$

Where

$ODEX_{i,t}$ = ODEX of sector i for year t (i= household, transport, industry and services)

$ES_{i,t}$ = Final Energy demand Share of sector i for year t

2.2.1 Household ODEX

The ODEX for the household sector is estimated by aggregating the UC trends of three end uses (space heating, water heating and cooking) and five large appliances (refrigerators, freezers, washing machines dishwashers

and TVs) based on their share in TFE demand of the household sector (equation 2). The UC trend for residential space heating can either be expressed i) per unit of floor space (m^2), or ii) per dwelling or (for comparison see section 3.8). The first option (i) was chosen for the ODEX methodology because it is closest to the technical efficiency and it does not depend on changes in the size of. The indicators for hot water and cooking are determined by dividing the respective final energy use by the number of occupied dwellings (this is reasonable because households typically have one stove or washing machine and division by floor area or the average number of inhabitants would be less meaningful). The UC for appliances is calculated as the ratio of annual final energy consumed by a particular appliance type and its stock (kWh/appliance/year). The UC indices of the individual appliance types are weighted by their share in TFE in order to establish an EE trend for all five large appliances.

2.2.2 Transport ODEX

The UC indices of eight transport modes (cars, trucks, light vehicles, motorcycles, buses, air transport, rail, and water transport) are aggregated using their final energy shares as weighting factors to establish the overall EE trend (equation 2). The EE of cars can be calculated based on several physical activity indicators viz. i) passenger-km (pkm), ii) vehicle-km (vkm) or iii) vehicle stock (see section 0 for comparison) [34]. For the estimation of transport ODEX, the EE indicator based on pkm is chosen which is a widely applied activity indicator. It provides a measure of EE, thereby accounting for distance travelled and occupancy level) along with an overview of modal shift at higher aggregation [47]. The activity indicator pkm (published as statistical data, see Appendix A) is the result of multiplying the number of passengers by the average distance per passenger. The UC for air transport is tracked using the energy consumed per passenger due to lack of data on pkm. For the same reason, the UC for buses and motorcycles is calculated as energy consumed per vehicle. For transport of goods by trucks, light vehicles and water transport, the UC is calculated by dividing final energy use by physical activity in tonne-km (tkm, published as statistical data) which is the result of multiplying the weight of goods (in tonnes) by the average distance of transport (in km). Due to transport of both passengers and freight by rail (pkm for passenger and tkm for freight), an aggregate indicator, Gross tonne-km (Gtkm)[1] is used to track physical activity.

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[1] The Gtkm indicator is calculated by weighting each passenger-km by a factor of 1.7 and each tonne-km by a factor of 2.5 (i.e. Gtkm = 1.7*pkm+2.5*tkm) (34.   ODYSSEE-MURE, *Definition of data and energy efficiency indicators in ODYSSEE database*.).

2.2.3 Industry ODEX

The ODEX for the industry sector is again a TFE-weighted aggregate of subsectoral UC indices (e.g. indexed form of calculated at the level of two-digit NOGA/NACE classification). UC indices for homogeneous and heterogeneous subsectors are established using different methodologies. The UC trends for the homogeneous subsectors such as steel, cement and paper production are determined using the change in TFE consumed per unit of physical output (kt) of the subsector (e.g., per tonne of cement). UC trends for heterogeneous subsectors such as food and beverage, chemicals and pharma, textile and leather or subsectors with data limitations due to confidentiality of physical production data such as machinery and fabrication, other primary metals (primary metals minus steel), other non-metallic minerals (non-metallic minerals minus cement) and printing are calculated as the change in energy demand relative to the change in production index proxy (PIP). The PIP is determined by deflating the turnover for each subsector (2-digit NOGA) by the producer price index. The process of deflation using the producer price index removes the effect of price changes from the turnover and results in the trend of physical production over time [48] (for details see Appendix B). While more traditional monetary indicators are not used for the EE trend analysis in the ODEX methodology, the comparison of physical EE and monetary EE (Energy demand/Value added) offers valuable insight into the effects of structural shifts occurring at the sectoral and subsectoral level.

2.2.4 Tertiary ODEX

The tertiary ODEX is calculated by aggregating EE trends for electricity and fuel demand based on their share in TFE of the service sector (see eq. 4). The EE trends of the service sector's for electricity and fuel demand are established by aggregating UC indices for electricity and fuel respectively for individual subsectors (public administration and government services building, offices, hotels & restaurants, hospitals, wholesale and retail trade services building and education buildings) based on their respective share in final energy (see eq. 5 and 6). The UC trend for electricity (and fuel) is estimated as the ratio of the subsector's electricity (and fuel) demand and its number of employees (as closest proxy for floor space in m^2; data on the latter are typically not available at the subsectoral level.).

$$I_{i,t-1}\Big/I_{i,t} = (\frac{UCE_t}{UCE_{t-1}}) \times ES_t + (\frac{UCF_t}{UCF_{t-1}}) \times FS_t \qquad (4)$$

Where

UCE_t and UCE_{t-1} = Unit consumption index for electricity demand of service sector year t and t-1 respectively (see eq. 5)

UCF_t and UCF_{t-1} = Unit consumption index for fuel demand of service sector for year t and t-1 respectively (see eq. 6)

ES_t = Share of electricity demand in TFE of services for year t

FS_t = Share of fuel demand in TFE of service sector for year t

$$UCE_t = \sum_j(\frac{UCE_{j,t}}{UCE_{j,t0}} \times ES_{j,t}) \qquad (5)$$

$$UCF_t = \sum_j(\frac{UCF_{j,t}}{UCF_{j,t0}} \times FS_{j,t}) \qquad (6)$$

Where,

$UCE_{j,t}$ and $UCE_{j,t0}$ = Unit consumption index for electricity demand of subsector j for year t and year t_0 respectively

$UCF_{j,t}$ and $UCF_{j,t0}$ = Unit consumption index for fuel demand of subsector j for year t and year t_0 respectively

$ES_{j,t}$ = Share of electricity of subsector j in electricity demand of service sector

$FS_{j,t}$ = Share of fuel demand of subsector j in fuel demand of service sector

The tertiary ODEX is then estimated based on equations 4 and 2.

2.3   Decomposition analysis

The variation in TFE demand of the complete country between two given years is decomposed into the activity effect (cumulative activity effect of all sectors), demography effect (number of dwellings), the effect of lifestyle (size of the dwellings and number of appliances per dwelling), the effect of structural change in industry, the effect of annual variations in climate[2] and other effects capturing the inefficiencies in the capacity utilization. The key influencing factors for the TFE demand of individual sectors are summarised in *Table 1*. Throughout the literature, the Log Mean Divisia Index methods (LMDI 1 and 2) are the preferred choice for the decomposition of TFE demand [23, 24, 49-52]. These LMDI methods generally consist of three-factor identity for the influencing factors and without any residual term [52], while the method used in the present paper

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[2] Contrary to all other totals of TFE demand presented in this paper, the total presented in the decomposition analysis is *not* climate corrected. This choice was made in order to display the effect of the difference in climate conditions in the base year and the target year.

consists of multiple effect identity for the decomposition of final energy demand[3] by sector and by influencing factor with a residual term capturing the effect of inefficient capacity utilization. The formulae developed for the present method mainly differ from LMDI methods in terms of the weighting function used to calculate the influencing factors. The chosen method has the advantage that the contribution of EE can be readily be derived from the trend of ODEX [49].

Table 1 Variables that explain the variation on final energy demand and used in the decomposition analysis for each sector

Sectors	Variables that explain the variation
Households	• Demographic effect: the effect of change in number of dwellings
	• Larger homes: the effect of change in floor area
	• Lifestyle effect: the effect of change in household equipment ownership
	• Climatic effect: the effect of annual change in climatic conditions[5]
	• Energy savings: the effect of technical development
	• Other effects: the effect of change in heating behaviour
Services	• Activity effect: the effect of a change in the value added of tertiary
	Note: the activity indicator chosen for decomposition (value added) differs from the one used for ODEX (number of employees, see section 3.4)
	• Productivity effect: the change in the ratio of the value added per employment
	• Climatic effect: the effect of annual change in climatic conditions
	• Energy savings: the decrease in the energy consumed per employee by subsector • Other effects
Transport	• Activity effect: the effect of change in activity, i.e. person-kilometres (pkm) for person transport and tonne-kilometres (tkm) for goods
	• Modal shift: the effect of change in the distribution of various transport modes within the sector
	• Energy savings: the effect of technical improvements
	• Other effects: the effect of inefficient utilization of capacity for goods transport
Industry	• Activity effect: the effect of change in the physical activity (measured by either physical production statistics or production index estimated from the turnover)
	• Structural effect: the effect of different rates of growth of energy intensive and non-energy-intensive subsectors of the industry
	• Energy savings: the effect of technical improvement
	• Other effects: the effect of inefficient utilization of capacity

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[3] The detailed formulae for estimation of explanatory factors are available in methodological report published by ODYSSEE-MURE (49. ODYSSEE-MURE, *Understanding variation in energy consumption - Methodological report*.). [5] The climatic effect is calculated by difference between the variation between t and t_0 (in our case 2016 and 2000, respectively) of the actual energy consumption and the variation between t and t_0 of the energy consumption with climatic corrections

2.4 Cross country comparison: Indicator scoreboard

Comparison of EE trends and policy measures across countries helps understanding the effectiveness of the strategy pursued to improve EE [3] and to save energy. This is facilitated by scoring and ranking the countries included in the ODYSSEE-MURE database according the level of energy consumption (level indicator), the rate of EE improvement (trend indicator) and the effectiveness of the policy measures implemented. The scores for level and trend are calculated for a list of selected indicators representative of end uses, transport modes or subsectors[4] and are normalised (between 1 to 0; 1 being the best) in order to assign the ranks. The normalised scores (level and trend) are then aggregated at the sectoral level for each country based on the TFE demand shares of end use, subsector or transport mode respectively. In contrast, no separate scores are estimated for industry at the level of subsectors. The level score for industry is based on *energy intensity* and is calculated assuming for all countries an adjusted EU average industry structure based on the shares of value added (creating a harmonised basis by assuming a common industry structure). The trend score for industry is based on *ODEX* which represents the *total* sector (ODEX is unit less and can therefore not be used as indicator for the level score). The calculation of the policy score consists of four steps including quantitative and semiquantitative information (see [53] for details). The three scores (level, trend and policy) calculated for the sectors are then aggregated to the country level based on their shares of TFE demand. Combined score for country is obtained in the same manner as at the sector level, i.e. by assigning 1/3 weight to trend, level and policy scores (see ***Figure 3***). The global scores are again normalised in order to assign overall rankings [53, 54].
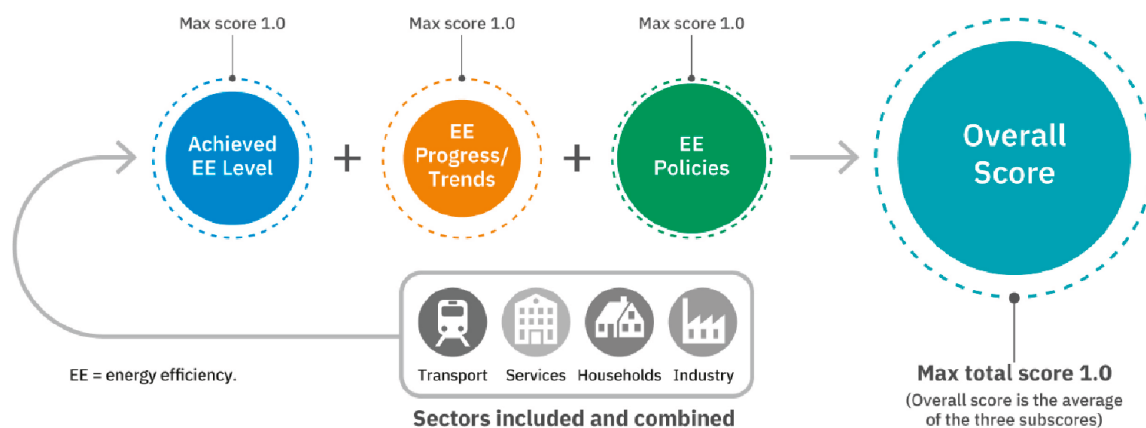

Figure 3 Indicator scoring methodology (*Source: eceee & ODYSSEE-MURE energy efficiency scoreboard for 2021, [53]***)**

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[4] Household – Space heating, other thermal uses, appliances, penetration of solar water heaters; Transport – Cars, trucks/light vehicles, air transport, modal split; Services – Fuel and Electricity consumption.

3   Results and discussion

3.1   Household sector

The trends of TFE demand and EE improvement (ODEX) are plotted in **Figure 4**. The Swiss household sector's TFE (with CC) in absolute terms decreased at an average annual rate of 0.6% while the floor area grew by 1.4% p.a. Based on the ODEX methodology, energy efficiency for final energy use in the household sector improved at the rate of 0.9% per year (i.e. 16.5% improvement in 20 years). The deterioration of ODEX in 2020 as visible in **Figure 4** can be expected to be related to the COVID pandemic, leading increased presence at home and consequently elevated energy use. The growth of floor area at an average annual rate of 1.4% was outpaced by the rapid efficiency improvement of the space heating (2.1% p.a.), resulting in an overall reduction of space heating demand of 0.7% p.a. The stock of electrical appliances grew at an average annual rate of 1.7%. The EE improvement rate of 0.3% p.a. helped to limit the TFE increase for appliances which amounted to 0.9% p.a. Graphs for the development of TFE, physical energy efficiency and activity for space heating, hot water, as well as lighting and appliances can be found in the slides of the National Odyssee-MURE Workshop for Switzerland in November 2021 (this is also the case for all other sectors covered in this report).
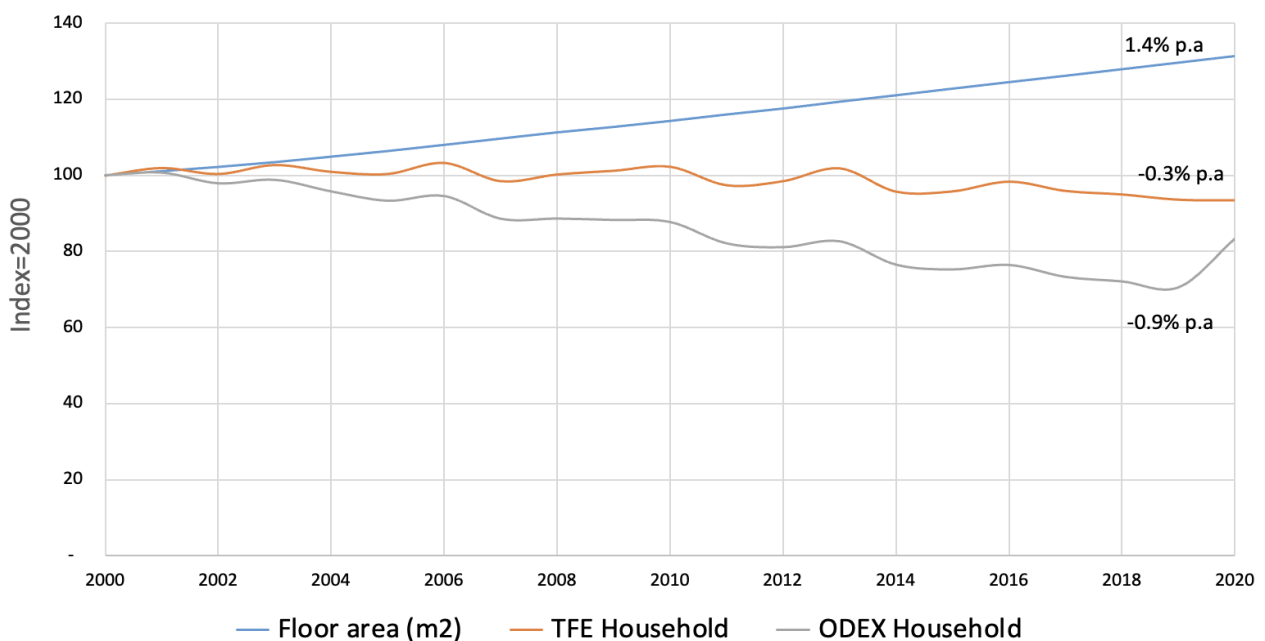

Figure 4 Swiss household sector - Trend of TFE demand (<u>with</u> climatic corrections, 2000-2020), activity (floor area) and unit consumption (UC)

The decomposition analysis (**Figure 5**) shows that the decrease of TFE demand (*nominal value*, <u>without CC</u> – first bar in **Figure 5**) of the Swiss household sector from 2000 to 2020 is exclusively caused by energy efficiency (-35%). Most of the related TFE savings are compensated by the higher number of dwellings (resulting in +23%

TFE), the larger number of appliances per dwelling (+4% TFE), larger homes (+2% TFE), climate effects (-0.4% TFE) and other effects (+0.4?).
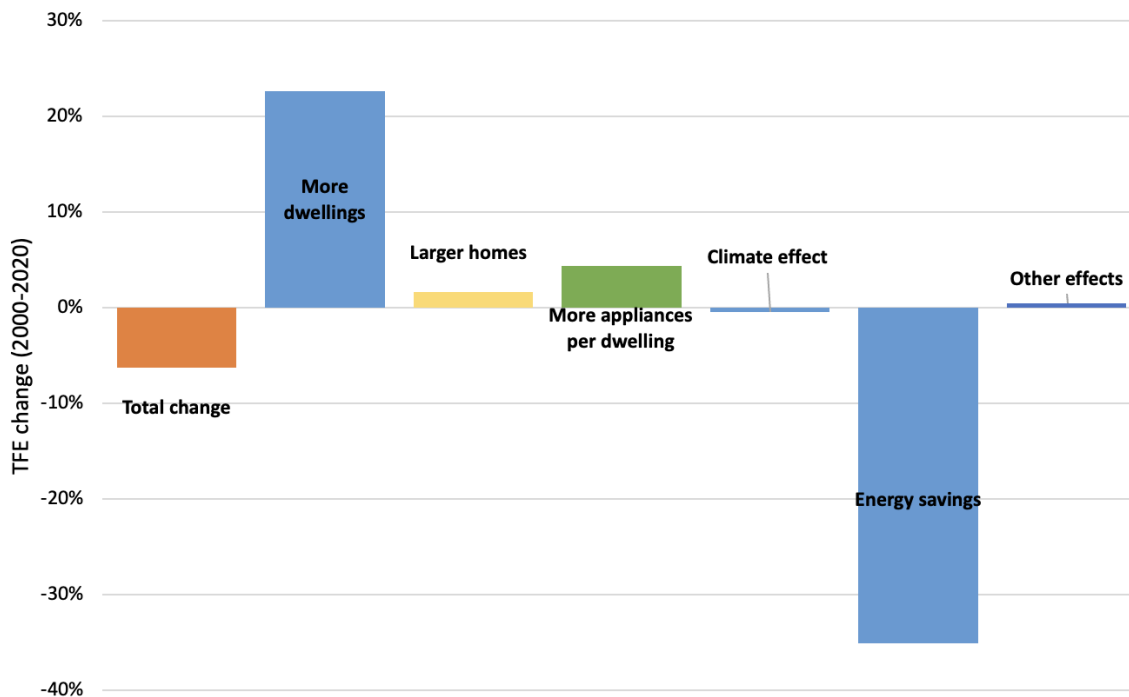

Figure 5 Swiss household sector - Decomposition analysis for TFE (2000-2020)

3.2 Transport sector

At the time of preparing this report, data for 2020 were available for all sectors except for transport. The analysis therefore covers the period 2000 to 2019 for the transport sector. As displayed in *Figure 6*, the activity of transport sector measured in pkm (for passenger transport) and tkm (for goods transport) grew at 1.5% and 1.1% p.a. respectively. Both transport activity and EE improvement were dominated by private transport. As a consequence of the EE improvement of the total transport sector (Transport ODEX) at a rate of 1.9% p.a. from 2000 to 2019 (30% overall improvement in 19 years), the transport sector's TFE in absolute terms hardly decreased (i.e., by only 0.2% p.a.; *Figure 6*). Cars and air transport, together responsible for around 75% of the TFE consumed by the Swiss transport sector, both improved their EE at a rate of 2.3% p.a. This is a higher improvement rate than found for trucks (0.9% p.a.), buses (0.01% p.a.) and rail transport (1.0% p.a.).
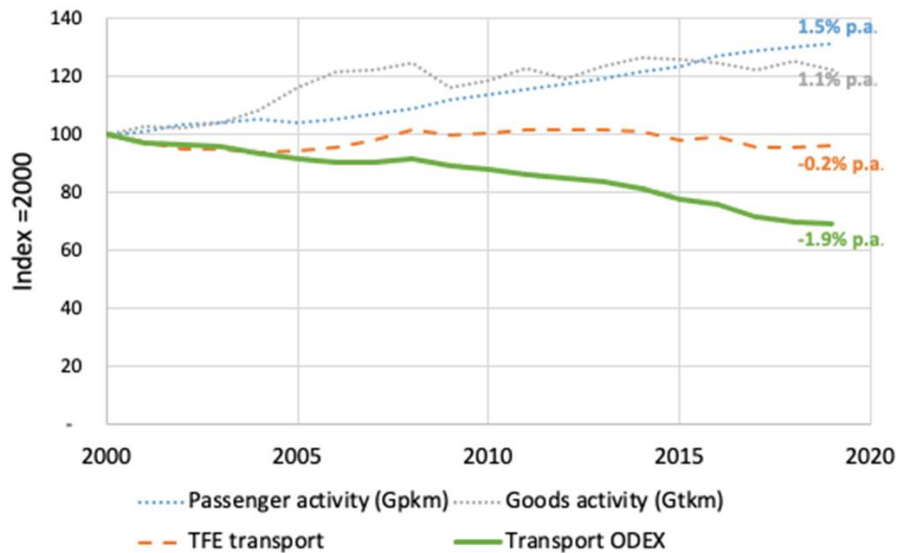
Figure 6 Swiss transport sector - Trend of physical EE, activity level and TFE demand (2000-2019)

Figure 7 presents the contribution of selected factors in the change of the Swiss transport sector's TFE demand from 2000 to 2019. For the total transport sector, the increase in activity (+26% TFE) and improved EE (-35% TFE) were the two main explanatory variables for the variation of TFE, with the two effects largely offsetting each other. The impact of modal shift (negligible contribution to TFE) and other effects (+2% TFE) was nearly negligible. As total effect of all these components, TFE decreased by 8% for the total transport sector, which includes a decrease (by -15% TFE) for passenger transport but an increase (by +7% TFE) for goods (*Figure 7*).
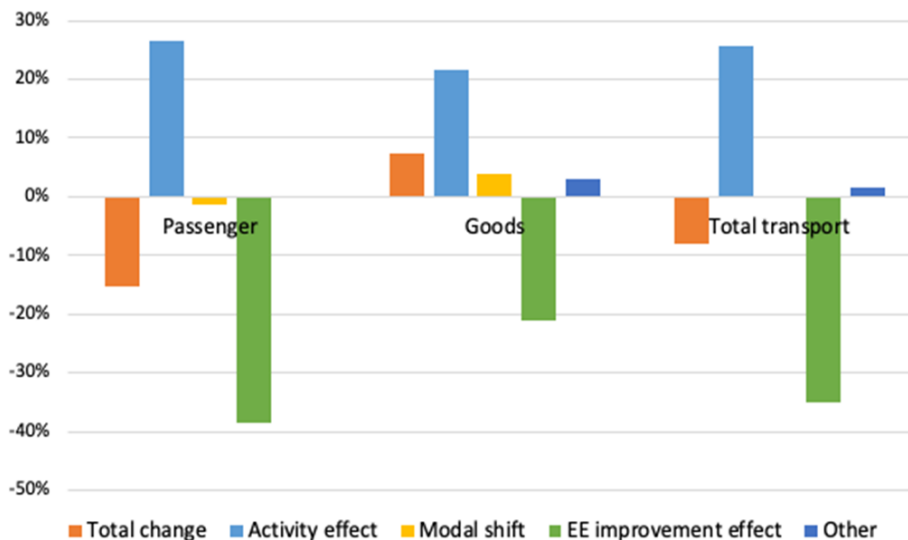

Figure 7 Swiss and EU transport sector - Decomposition analysis for TFE (2000-2019)

3.3   Industry sector

As displayed in *Figure 8*, the TFE demand of the total Swiss industry decreased at a rate of 0.7% p.a. in spite of an increase in the activity by 1.5% p.a. Based on the industry ODEX calculation (see section 2.2.3), the EE of

the Swiss industry improved at a moderate rate of 1.5% p.a. from 2000 to 2020 (26% improvement overall in 20 years).

As evidenced by the physical activity indicator, both the paper sector (-1.7% p.a.) and primary metals manufacturing (-0.5% p.a.) experienced a decrease in their output between 2000 to 2020. The cement sector (+0.5% p.a.) experienced a slight increase in its output, the food and beverage sector grew at a moderate rate (+1.5% p.a.), while the growth of the chemical sector (including pharmaceuticals) was very significant (+4.6% p.a.). Physical production of total industry grew by 1.5% p.a.

The average annual rate of physical EE improvement was highest in the chemical sector (by 3.2% p.a.), closely followed by paper manufacturing (2.8% p.a., possibly due to consolidation of the sector). On the other hand, EE improvement was low in the remaining sectors, i.e., 0.6% p.a. both for cement and primary metals and 0.8% p.a. for food and beverages. For industry as a whole, EE improved by 1.5% p.a., which is rather respectable-

As a result of these changes in activity and EE, TFE slightly increased (by 0.7% p.a. for food and beverages) or slightly decreased (by 0.1% p.a. for cement, by 0.5% p.a. for chemicals, by 1.0% p.a. for primary metals), with the exception of paper manufacturing whose TFE very significantly decreased by 4.9% p.a. Total industry's TFE
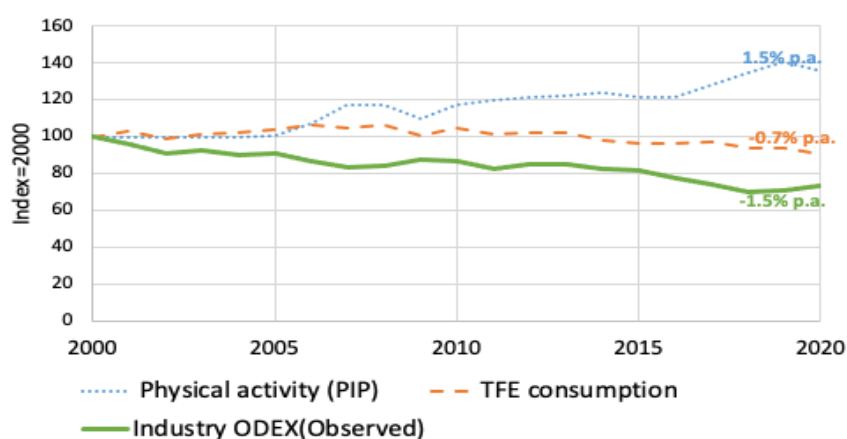

Figure 8 Swiss industry sector - Trend of Physical EE, activity level and TFE demand (2000-2020)

Figure 9 shows the decomposition analysis performed for the industry sector. Although the physical activity of the Swiss industry sector increased significantly from 2000 to 2020 (+46% TFE), the combined effect of structural change (-34% TFE) and EE improvement (-40% TFE) resulted in clear a decrease of the Swiss industry's TFE demand (-19% TFE). Structural change (implying here that subsectors whose products are characterized by a relatively low Specific energy consumption (SEC) grew faster than subsectors characterized by products with high SEC) hence reduced TFE to a similar extent as EE improvement. In fact, the production level of the subsector with the highest SEC, paper and pulp production, decreased while the subsectors with low SECs such as cement and steel grew relatively fast, thus contributing to lowering of the TFE.
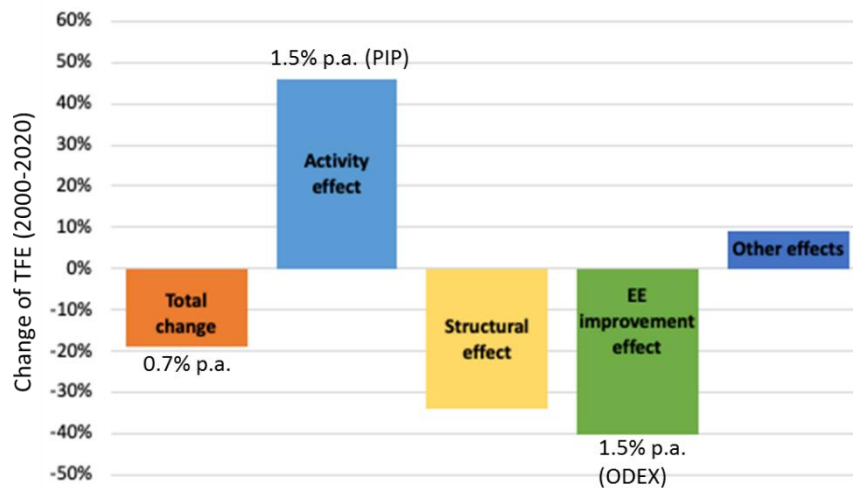
Figure 9 Swiss and EU industry sector - Decomposition analysis for TFE (2004-2019)

3.4   Service sector

The activity of service sector, measured in the number of employees, grew at an average annual rate of 1.4%, while the value added increased at the rate of 2.3% per year. The average annual improvement of physical EE (tertiary ODEX, based on employees) at the rate of 1.9%, together with a negligible contribution of structural change (not displayed), resulted in a reduction of TFE demand (with CC) of the Swiss service sector at a rate of 0.7% p.a. from 2000 to 2020 (see *Figure 10*). The EE of "Private offices", improved at the fastest rate (4.0% p.a.) amongst the subsectors of Swiss service sector followed by both public offices (2.6% p.a.) and health & social work (2.1% p.a.). In contrast, the rate of total final EE improvement was lowest for hotels and restaurants (0.4% p.a.), followed by education (1.0% p.a.) and retail (1.2% p.a.; all values for the period from 2000 to 2020).
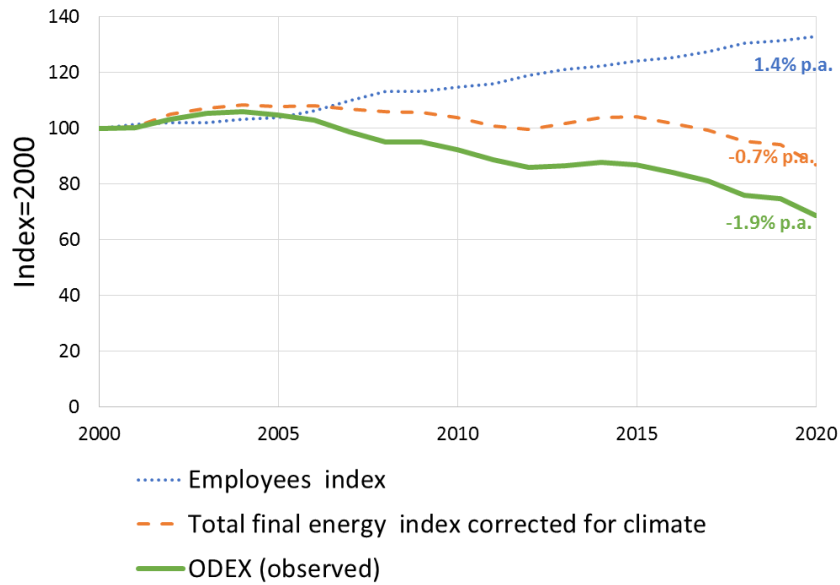
Figure 10 Swiss service sector - Trend of physical EE, activity level and TFE demand (with climatic corrections, 2000-2020)

The decomposition analysis presented in *Figure 11* shows that TFE demand of the service sector decreased slightly (by 5%, <u>without CC</u>; first bar in *Figure 11*) from 2000 to 2020. The improvement of EE (-30% TFE) and employee productivity (Value added/employee; -25% TFE) contribute significantly to TFE demand reduction. They overcompensate the impact of activity growth in terms of value added (+47% TFE), together with the negligible contribution of the climatic effect (<1% TFE) and of other factors (<1% TFE). Although the UC in ODEX calculation is based on the activity indicator "number of employees" (as the closest proxy for floor space), the value added is better suited as the activity indicator to measure the different growth rates of subsectors since it represents their economic output.
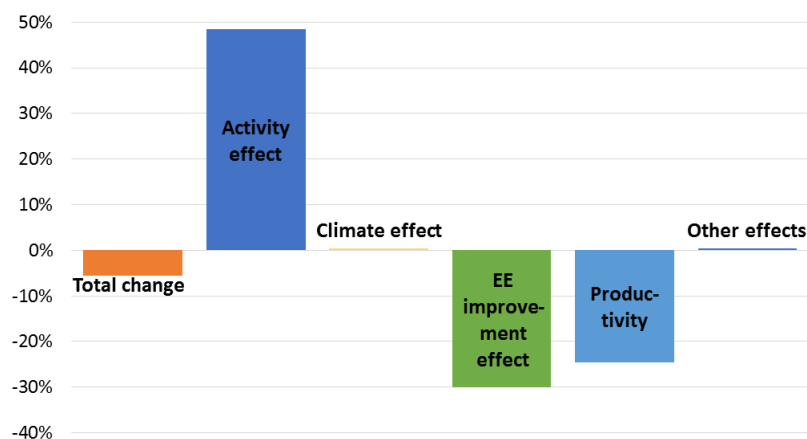

Figure 11 Swiss and EU service sector - Decomposition analysis for TFE (2000-2019)[5]

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[5] The activity indicator used for decomposition analysis is value added.

3.5 Overall Switzerland

The analysis for Switzerland as a whole covers the period 2000 to 2019 because at the time of preparing this report, data for 2020 were not yet available for transport. The TFE demand of Switzerland (with CC) decreased at an average annual rate of 0.5% in the period from 2000 to 2019. The growth of GDP (in constant Euros) for the same period was recorded at 2.4% p.a. resulting in an average annual improvement of 2.8% in energy intensity (TFE demand/GDP) of Switzerland. As shown in *Table 2*, the physical EE of Switzerland improved at an average rate of 1.7% per year (observed global ODEX). All the individual sectors in Switzerland experienced growth in their respective activities during the years 2000 to 2019 (*Table 2*). The TFE demand of all sectors decreased during the same period, however only very slightly for households, services and transport. The transport sector experienced the fastest EE improvement rate (1.9% p.a.) whereas services were the slowest sector to improve their EE (1.5% p.a. until 2019).

Table 2 Average annual rates of change (activity, TFE and ODEX) for all Swiss sectors, 2000-2019 (since transport data is only available until 2019 the time period 2000-2019 is considered for the entire table)

Sector	Share of TFE	Activity	TFE demand (with CC)	EE improvement (ODEX)
Household	29%	1.4% (floor space) 1.2% (dwellings) 1.7% (appliances)	-0.3%	1.8%
Transport	33%	1.5% (pkm) 1.1% (tkm)	-0.4%	1.9%
Industry	19%	1.8% (PIP)	-1.0%	1.8%
Services	18%	1.4% (employees)	-0.3%	1.5%
Total	100%	2.4% (GDP)	-0.5%	1.7 % (Global ODEX)

Figure 12 shows the decomposition analysis of TFE demand for the entire country. The overall growth of physical activity of the Swiss economy and of the residential sector (bar "Activity"; +34% TFE) implies an increase in TFE demand. These effects were primarily overcompensated by energy savings across all the sectors of the economy (-36% TFE; here so-called technical savings[6]) and in addition some structural changes (esp. in industry, -6%) as well as other effects (-3%). As a consequence, TFE demand decreased by around 80 PJ (=740 – 660) or by 11% from 2000 to 2019.

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[6] These "technical energy savings" are somewhat larger than the "observed energy savings"; see Odyssee methodology for explanations.
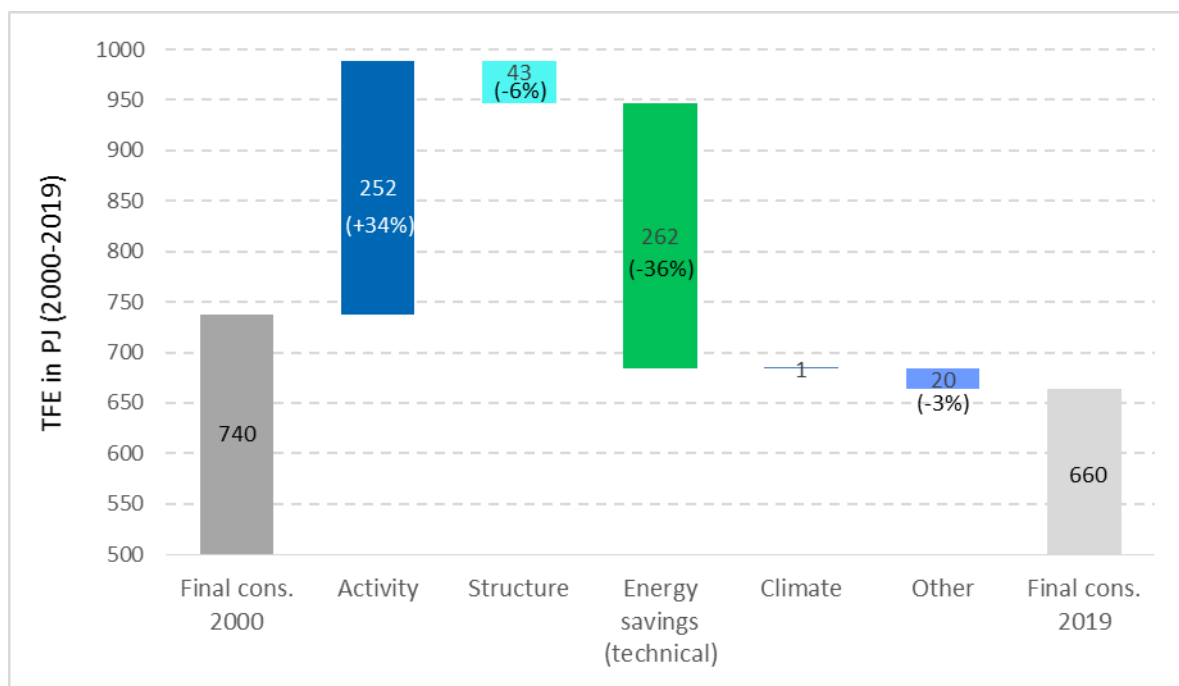
Figure 12 Decomposition analysis of TFE variation for Switzerland (all sectors), 2000-2019
(Data source: Odyssee-MURE web interface)

3.6   Cross-country comparisons

As a consequence of incomplete data availability (see above), cross-country comparisons can only be made for the period 2000-2019 (excluding year 2020). Based on the scores calculated following the methodology explained in Section 2.4, Switzerland is at the first rank in terms of the overall combined score (including all sectors as well as the three indicators Level, Trend and Policies; see top row of *Table 3*). Among the four sectors, Switzerland scores outstandingly well for both households and services (ranked first in both) as well as for industry (ranked fourth). Only for transport, Switzerland is positioned at a mediocre level (16th). The first ranks for households and services is the consequence of the very good ranks of all subcategories, remaining among the top-five for Level, Trend and Policies. The rather high rank for industry is enabled by the high score for Level (ranked first) which is partly related to the definition of the indicator: due to the high value added of Swiss industry, industrial energy intensity is exceptionally low, resulting in this excellent score. It should, however, be kept in mind that, as sole exception within the scoreboard and as a consequence of lack of data, this is an economic instead of a physical EE indicator; possibilities for quantifying the EE level by a physical metric should therefore be addressed by future research. The trend indicator for industry is ranked 10th which is respectable. Within the transport sector, the rapid diffusion of more efficient vehicles puts Switzerland within the first third for the rate of EE improvement (trend), with possible reasons being the increased number of hybrid and some fully electric cars as well as the growing share of diesel cars at the expense of petrol cars. However, Switzerland is one of the least performing countries (26th) in terms of the UC (level) in the transport sector. One of the reasons may be that the Swiss car fleet is characterized by a large share of vehicles with

high engine capacity in Europe (23% cars with engine capacity more than 2000 cm^3 [35]), thus consuming more fuel per pkm as compared to most of other countries included in the ODYSSEE database. As *Table 4* finally shows, Switzerland ranks among the top 6 countries for all three of the aggregated indicators on level, trend and policies.

Table 3 Overall ranking by country based on combined score (incl. level, trend and policies) and by sector

Overall (all sectors)

	Level	Trend	Policies	Combined
1 **Switzerland**	**0.96**	**0.88**	**0.653**	**0.831**
2 Ireland	0.81	0.69	0.81	0.77
3 Estonia	0.62	0.59	1.00	0.74
4 Romania	0.54	0.92	0.68	0.71
5 France	0.62	0.52	0.87	0.67

Households

	Level	Trend	Policies	Combined
1 **Switzerland**	**0.94**	**0.85**	**0.84**	**0.88**
2 Finland	1.00	0.73	0.56	0.76
3 France	0.72	0.67	0.88	0.76
4 Ireland	0.85	0.80	0.57	0.74
5 Netherlands	1.00	1.00	0.11	0.70

Transport

	Level	Trend	Policies	Combined
1 France	0.86	0.66	0.93	0.82
2 Romania	1.00	0.85	0.55	0.80
3 Ireland	0.65	0.69	1.00	0.78
4 UK	0.77	0.58	0.75	0.70
5 Estonia	0.80	0.42	0.84	0.69
16 **Switzerland**	**0.61**	**0.72**	**0.28**	**0.53**

Industry

	Level	Trend	Policies	Combined
1 Estonia	0.90	0.95	0.59	0.81
2 Romania	0.54	0.76	0.75	0.68
3 Denmark	0.93	0.53	0.32	0.59
4 **Switzerland**	**1.00**	**0.36**	**0.32**	**0.56**
5 Cyprus	0.85	0.67	0.06	0.52

Services

	Level	Trend	Policies	Combined
1 **Switzerland**	**0.91**	**0.60**	**0.95**	**0.82**
2 UK	0.88	0.55	0.59	0.67
3 Romania	1.00	0.42	0.57	0.66
4 Germany	0.76	0.57	0.55	0.63
5 Slovakia	0.68	1.00	0.17	0.62

Table 4 Overall ranking by country for Level, Trend and Policy (all sectors accounted for)

	Level			Trend			Policies	
1 Lithuania	1		1 Greece	1		1 Estonia	1.00
2 **Switzerland**	0.96		2 Luxembourg	0.96		2 France	0.87
3 Spain	0.85		3 Romania	0.92		3 Ireland	0.81
4 Denmark	0.83		4 **Switzerland**	0.88		4 Germany	0.68
5 Ireland	0.81		5 Croatia	0.81		5 Romania	0.68
						6 **Switzerland**	0.65

4   Conclusions

In Switzerland, Total Final Energy (TFE) demand (with CC) decreased by 0.5% p.a. from 2000 to 2019, while the economy (GDP) grew at a rate of 2.4% per year. This points to some decoupling of economic growth and energy consumption, however without providing insight into the rate of improvement of *physical* energy efficiency (EE). To study the latter, the Odyssee energy efficiency index (ODEX) was analysed for individual sectors and at the country level. It has been found that physical EE of Switzerland (global ODEX) improved at an average annual rate of 1.7% (observed global ODEX) and that it was accompanied by some structural change. Across the various sectors, the progress in physical EE ranges between 1.5% p.a. and 1.9% p.a. for the time period 2000-2019 (the range is wider for the period 2000-2020, spanning from 0.9% p.a. to 1.9% p.a.). Physical EE in the sectors transport and services, responsible for 33% and 18% of Switzerland's TFE demand respectively, improved at 1.9% p.a. and at 1.5% p.a. respectively (for 2000 to 2020 at 1.9% p.a. for services; for transport, no data are available until 2020). Households, responsible for 29% TFE, experienced a significant physical EE improvement pf 1.8% p.a. in the period 2000-2019 (but only 0.9% p.a. in the period 2000-2020, arguably due to Covid). Finally physical EE of industry, representing 19% of TFE, improved at a rate of 1.8% p.a. from 2000 to 2019 (and by 1.5% p.a. from 2000 to 2020). TFE decreased for all sectors, but only very slightly for all sectors except for industry with a moderate TFE demand decrease of 1.0% p.a. The results of decomposition analysis for the period between 2000 and 2020 (for transport only until 2019) show that for all sectors most or – in the case of industry - all of the energy savings enabled by EE improvement are outweighed by higher activity levels. For industry, structural change contributes to additional energy savings, hence enabling a decrease of TFE also in this sector.

The cross-country comparisons show that Switzerland ranks first after Ireland and Estonia amongst the countries included in ODYSSEE-MURE database based on the combined consideration of EE level, EE trend and EE policy. All the individual sectors in Switzerland rank among the top four positions except for transport that ranks 16th.

From 2000 to 2019, Switzerland's EE improved faster than most of the countries represented in ODYSSEE database (Switzerland is ranked fourth). The overall first rank for Switzerland is the outcome of combining the result for the EE trend (ranked fourth) with the high scores on the level of EE (ranked second) and for policy (ranked sixth). Further work would be required to update the results once all statistical data are available for 2020 and to compare the achievements with the policy targets. More fundamentally, ways should be explored to improve the indicator on the EE level (in order to represent physical rather than monetary energy efficiency) and to consider the further course of policy making after the rejection of a newly proposed CO_2 law by the Swiss electorate in a public referendum in June 2021.

Acknowledgements

References

1.   Farla, J., *Physical Indicators of Energy Efficiency*. 2000.
2.   Bosseboeuf D., C.B., Lapillonne B., *Cross-country comparison of energy efficiency indicators: On-going European effort towards a common methodology.* Energy Policy, 1997. **25**.
3.   European Parliament and Council: *Proposal for a Directive of the European Parliament and of the Council on energy efficiency (recast).* COM/2021/558 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021PC0558, 2021   and
        Energy Efficiency Directive. 2018; Available from: https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive.
4.   European Council: *Directive on the Energy Performance of Buildings*, in *Official Journal of European Journal*. 2010:   https://eur-lex.europa.eu/legalcontent/EN/TXT/PDF/?uri=CELEX:32018L0844&from=EN.
5.   European Council: Council, E., *Directive on Energy Performance of Buildings (Amendment)*, in *Official Journal of European Union*. 2018: https://eur-lex.europa.eu/legalcontent/EN/TXT/PDF/?uri=CELEX:32018L0844&from=EN.
6.   IEA, *Energy Policy Highlights: In-Depth Energy Policy Reviews (IDRs) of 21st Century*, in *Energy Policies of IEA Countries*. 2014, OECD Publishing, Paris: https://doi.org/10.1787/9789264200630-en.
7.   European Commission: Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality.   COM/2021/550   final,   https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0550, 2021
8.   IEA, *Capturing the Multiple Benefits of Energy Efficiency*. 2014:
        https://www.iea.org/publications/freepublications/publication/Multiple_Benefits_of_Energy_Efficiency.pdf.
9.   IEA, *Energy Efficiency Insights Brief*. 2017.
10.   EU. *Energy Efficiency*. Available from: https://ec.europa.eu/energy/en/topics/energyefficiency/eu-targets-energy-efficiency.
11.   PROGNOS, *Die Energieperspektiven für die Schweiz bis 2050, Energienachfrage und Elektrizitätsangebot in der Schweiz 2000 – 2050*. 2012, BFE: Basel.
12.   IEA, *Energy Policies of IEA Countries - Switzerland 2018 Review*. 2018.
13.   Phylipsen, G.J.M., *Energy Efficiency Indicators: Best practice and potential use in developing country policy making*. 2010.
14.   Tanaka, K., *Assessment of energy efficiency performance measures in industry and their application for policy.* Energy Policy, 2008. **36**(8): p. 2887-2902.
15.   Giacone, E. and S. Mancò, *Energy efficiency measurement in industrial processes.* Energy, 2012. **38**(1): p. 331-345.
16.   Proskuryakova, L. and A. Kovalev, *Measuring energy efficiency: Is energy intensity a good evidence base?* Applied Energy, 2015. **138**: p. 450-459.
17.   Ang, B.W., *Monitoring changes in economy-wide energy efficiency: From energy–GDP ratio to composite efficiency index.* Energy Policy, 2006. **34**(5): p. 574-582.
18.   Ang, B.W., A.R. Mu, and P. Zhou, *Accounting frameworks for tracking energy efficiency trends.* Energy Economics, 2010. **32**(5): p. 1209-1219.
19.   IEA, *Energy Efficiency* in *Market report*. 2017.

20. Horowitz, M.J. and P. Bertoldi, *A harmonized calculation model for transforming EU bottomup energy efficiency indicators into empirical estimates of policy impacts.* Energy Economics, 2015. **51**: p. 135-148.

21. Patterson, M.G., *What is energy efficiency? Concepts, indicators and methodological issues.* Energy policy, 1996. **24**(5).

22. ODYSSEE-MURE. *Energy efficiency indicators in Europe*. 2018; Available from: http://www.odyssee-indicators.org/index.php.

23. Ang, B.W., *A survey of index decomposition analysis in energy and environmental studies.* Energy, 2000. **25**: p. 1149–1176.

24. Ang, B.W., *Decomposition analysis for policymaking in energy.* Energy Policy, 2004. **32**(9): p. 1131-1139.

25. Wu, L.-M., et al., *Structure model of energy efficiency indicators and applications.* Energy Policy, 2007. **35**(7): p. 3768-3777.

26. Al-Mansour, F., *Energy efficiency trends and policy in Slovenia.* Energy, 2011. **36**(4): p. 18681877.

27. Song, C., et al., *Research on energy efficiency evaluation based on indicators for industry sectors in China.* Applied Energy, 2014. **134**: p. 550-562.

28. Saygin, D., et al., *Benchmarking the energy use of energy-intensive industries in industrialized and in developing countries.* Energy, 2011. **36**(11): p. 6661-6673.

29. Mondal, M.A.H., et al., *Ethiopian energy status and demand scenarios: Prospects to improve energy efficiency and mitigate GHG emissions.* Energy, 2018. **149**: p. 161-172.

30. Gielen, D. and P. Taylor, *Indicators for industrial energy efficiency in India.* Energy, 2009. **34**(8): p. 962-969.

31. Allouhi, A., et al., *Energy consumption and efficiency in buildings: current status and future trends.* Journal of Cleaner Production, 2015. **109**: p. 118-130.

32. Ruzzenenti, F. and R. Basosi, *Evaluation of the energy efficiency evolution in the European road freight transport sector.* Energy Policy, 2009. **37**(10): p. 4079-4085.

33. IEA, *Energy Efficiency Indicators Highlights*. 2018.

34. ODYSSEE-MURE, *Definition of data and energy efficiency indicators in ODYSSEE database*.

35. ODYSSEE-MURE, *Odyssee database (Subscription based database)*. 2021.

36. FSO, *Industries production account* 2020.

37. SFOE, *Schweizerische Gesamtenergiestatistik 2020*. Published in 2021.

38. SFOE, *Analyse des schweizerischen Energieverbrauchs 2000 - 2016 nach Verwendungszwecken*. 2017.

39. BFE, *Schweizerische Gesamtenergiestatistik 2020*. 2021.

40. SFOE. *Energy policy*. Available from: https://www.bfe.admin.ch/bfe/en/home/policy/energypolicy.html.

41. SFOE. *The first set of measurs*. 2018; Available from: https://www.bfe.admin.ch/bfe/en/home/policy/energy-strategy-2050/the-first-set-ofmeasures.html.

42. Council, T.F. *Energy regulation*. 2018; Available from: https://www.admin.ch/opc/de/classified-compilation/20162945/index.html.

43. SFOE. 2018; Available from: https://www.bfe.admin.ch/themen/00526/00541/00542/02167/index.html?lang=de&dossier_id=06722.

44. (SFAO), S.F.A.O., *Evaluation of incentive effect of emissions trading scheme Federal Office for the Environment*.

45. Confederation, S., *Switzerland's Seventh National Communication and Third Biennial Report under the UNFCCC Fourth National Communication under the Kyoto Protocol to the UNFCCC*. 2018:

https://unfccc.int/sites/default/files/resource/624078315_Switzerland-NC7-BR3-1CHE_NC7_BR3_2018.pdf.

46.   EnAW, *DER PARTNER FÜR KLIMASCHUTZ UND ENERGIEEFFIZIENZ*. 2016.

47.   IEA, *Energy Efficiency Indicators: Fundamentals on Statistics*. 2014:
        https://www.iea.org/publications/freepublications/publication/IEA_EnergyEfficiencyIndicat
        orsFundamentalsonStatistics.pdf.

48.   *International Recommendations for the Index of Industrial Production*, in *Series F No. 107*. 2010:
        https://unstats.un.org/unsd/industry/Docs/F107_edited.pdf.

49.   ODYSSEE-MURE, *Understanding variation in energy consumption - Methodological report*.

50.   Duran, E., C. Aravena, and R. Aguilar, *Analysis and decomposition of energy consumption in the Chilean
        industry.* Energy Policy, 2015. **86**: p. 552-561.

51.   Trotta, G. *Energy efficiency trends in the European Union: decomposition analysis and policy
        implications*. 2018. DOI: 10.13140/RG.2.2.31271.24484.

52.   Goh, T. and B.W. Ang, *Tracking economy-wide energy efficiency using LMDI: approach and practices.*
        Energy Efficiency, 2018.

53.   ODYSSEE-MURE, *ODYSSEE Scoreboard methodology*. 2021.

54.   Wolfgang Eichhammer, S.V., Meggan Kelly, Barbara Scholmann, *Comparing energy efficiency
        scoreboard methodologies and results*, in *ECEEE summer study*. 2017.

55.   ODYSSEE-MURE. *Decomposition tool*. 2021; Available from:
        http://www.indicators.odysseemure.eu/decomposition.html.

56.   SFOE, *Energieverbrauch in der Industrie und im Dienstleistungssektor* 2020, oublished in 2021.

57.   FSO, *Comptes de l'énergie des ménages et de l'économie, par branches et par agents énergétiques, en
        TJ*. 2020.

58.   PROGNOS, *Analyse des schweizerischen Energieverbrauchs 2000 - 2020 nach Verwendungszwecken*.
        2021, BFE.

59.   Prognos, INFRAS, TEP, ECOPLAN: Energy Perspectives 2050+. Short report (Kurzbericht)
        https://www.bfe.admin.ch/bfe/en/home/policy/energy-perspectives-2050-plus.html, 2020/2021