CACTUS

STRENGTHENING CENTRAL AND EASTERN EUROPEAN CLIMATE TARGETS THROUGH ENERGY SUFFICIENCY

The role of energy sufficiency in decarbonising the building and transport sectors in Hungary

Policy brief

May 2022

REKK FOUNDATION

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The role of energy sufficiency in decarbonising the building and transport sectors of Hungary

Policy Brief

prepared as part of the EUKI project "Consolidating Ambitious Climate Targets with End-Use Sufficiency" (CACTUS)

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Table of Contents

Introduction

Beyond the transformation of energy supply systems, the evolution of energy demand will also play crucial role in the EU reaching its net-zero emission target by 2050. Evidence shows that economic development and rising welfare might lead to higher demand for energy services, e.g. families tend to build larger homes, have more than one car, or fly more often to remote countries for holiday. These changes might limit or even negate the results of costly energy efficiency upgrades. In the EU, transport GHG emissions were 25% above 1990 levels in 2019 even with stricter vehicle emission standards, mainly due to increasing road traffic and aviation activities (EEA, 2021). According to EEB (2021), savings in carbon emissions in the EU from energy efficiency improvements in buildings in the period 1990-2018 were offset by raised emissions due to the increase in per capita floor area in wealthier countries.

Policy measures that can influence how society consumes energy services should be considered as one of the most important mitigation options in decarbonisation scenarios used for national policy planning (Barrett et al., 2021). The need for quick and effective energy demand reduction has recently become even more pronounced in the light of the EU's ambition to become independent of Russian energy sources. Hungary imports more than 85% of its natural gas and around 60% of its oil from Russia, which is a high challenge to replace.[1]

The term '*sufficient*' means 'as much as you need' or 'the quality of being good enough'. *Energy sufficiency* relates to energy consumption levels which provide a decent quality of living without endangering the carrying capacity of the Earth (Samadi et al. 2016, Förster et al. 2019, Lorek and Spangenberg, 2019). Reaching sufficiency goals entails absolute reductions in the consumption of energy through behaviour and lifestyle change (Zell-Ziegler et al. 2021), which can be fostered by policies incentivizing and guiding societal attitudes while improving the infrastructure (e.g., the construction of cycling lanes).

The purpose of this policy brief is to show how energy sufficiency policies could be applied in the Hungarian transport and building sectors. Drawing on estimated sufficiency potentials in literature and historic consumption trends, it proposes sufficient levels for core indicators and presents examples of related policy measures that have been successfully introduced in other countries. It also provides some insight into the possible energy savings for a selected set of indicators.

The first chapter provides a brief overview of the current regulatory landscape, checking how the concept of sufficiency is reflected in Hungarian climate regulation. The second chapter zooms into energy use in the building and transport sectors and proposes sufficiency levels for key indicators, based on estimates found in the literature. It also highlights some related policy options and good practices from other countries. The third chapter presents the results of an initial modelling exercise showing the impact on energy savings and cost savings of the 2050 target values of a few selected indicators, done with the purpose of checking the possible scale of reductions that could be achieved if sufficiency potentials could be realized. The last section summarises the key findings and recommendations, taking into account feedback from national policy makers.

[1] https://www.iea.org/reports/reliance-on-russian-fossil-fuels-data-explorer

1

1. National regulatory context: Policy measures and sufficiency in the buildings and transport sectors

The most important strategic documents setting out objectives and measures in relation to the **buildings sector** are the National Building Energy Strategy (2015), the National Energy and Climate Plan (NECP), the National Energy Strategy (NES), the National Clean Development Strategy (the long-term strategy of Hungary, LTS), and the Long-term Renovation Strategy of Hungary (LTRS) (Hungarian Ministry of Innovation and Technology, 2020b, 2020c, 2020a, and 2020d). All of them identify the highest potential for energy savings in the modernisation of residential buildings and heating systems. According to the NECP, there is potential to replace 1/4 of natural gas imports by 2030. Modernisation projects in the retail sector are planned to be implemented by the introduction of ESCO financing schemes through energy efficiency obligations for retail energy trade undertakings. The NES anticipates that the share of decarbonised, near-zero energy residential buildings will reach 33% by 2030. The LTRS envisages the full decarbonisation of residential and non-residential buildings by 2050 through deep renovation, use of renewable energy sources and intelligent systems, also facilitating the strategic objectives of lowering primary energy consumption and energy imports. It is expecting 20% energy savings in the household sector by 2030, a 60 % reduction in GHG emissions by 2040 (in comparison to the 2018-2020 average) and 90% near zero-energy building stock by 2050. The LTS asserts that the largest energy savings potential lies in the residential sector, reaching 70 PJ by 2050. Energy sufficiency has not yet appeared on the strategic policy agenda for buildings.

Turning to the **transport sector**, Hungary's NECP projects emission reductions through switching to renewable energy sources and enhancing energy efficiency. Although stressing the importance of decoupling economic growth and energy consumption, the strategy does not set out to lower demand reduction, claiming that economic growth should not be constrained by limiting energy use. Besides the goal of reaching a 14% share of renewable energy by 2030, it limits the growth of petroleum product use to 10% by 2030. Specific measures mainly target electrification, but it also aims to encourage modal shift and the development of intermodal transport, by providing tax advantages for combined freight transportation. The Hungarian Transport Infrastructure Development Strategy (Hungarian Ministry of National Development, 2014) outlines measures limiting private transport demand, such as the improvement of service quality in public transportation (increased availability and convenience, shorter travel time, better connections, intelligent passenger information systems) and the promotion of non-motorized modes by establishing new biking facilities and creating low-traffic zones. These goals are also set out in the Budapest Mobility Plan (BKK, 2015), which also draws attention to the importance of awareness raising of travellers. The NES sets out objectives that can also facilitate reaching sufficiency goals, such as the promotion of alternative modes (car-sharing, car-pooling, bike-sharing, use of bicycles and more efficient transport planning) and encouraging teleworking. The National Clean Development Strategy (LTS) recognises that reducing GHG emissions in the transport sector will be a large challenge in sight of the steadily rising demand for mobility services, projecting an 8 PJ increase in energy consumption by 2050 even in the early action climate neutrality scenario. To reach the 90% emission reduction goal set for the sector, the strategy highlights that incentives for public transportation, cycling and car sharing will be critical. Therefore, in the field of transport, although not explicitly, some actions are identified that serve sufficiency objectives.

2

2. GHG emission and energy consumption trends

Figure 1 shows the evolution of Hungary's GHG emissions in the household and transport sectors between 2005 and 2019. (Eurostat, 2021a). Household emissions fell by more than 30% over the period, more than the EU average. However, transport emissions grew much faster than the EU average following the economic crisis in 2013.

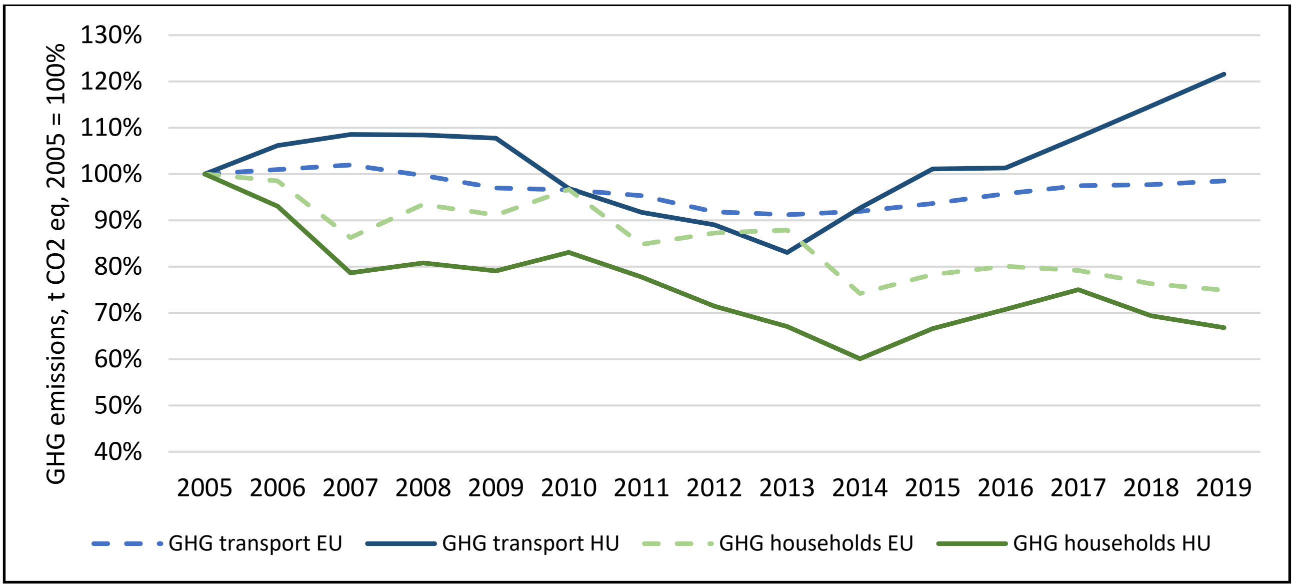

Figure 1: Household and transport greenhouse gas emissions in Hungary and the EU27, 2005 – 2019, 2005 = 100%. Source: Eurostat (2021a)

Figure 2 shows that per capita transport energy use was rising between 2013 and 2019, and although still well below the EU average, it is gradually approaching the EU level (Eurostat, 2022a). Household energy use in Hungary is higher on average than in the EU, falling by 19% between 2005 and 2019 (Eurostat, 2022), and the corresponding reduction in GHG emissions (as shown by the previous figure) was much higher (around 30%), suggesting significant improvements in the GHG intensity of the energy sources used for heating and cooling.

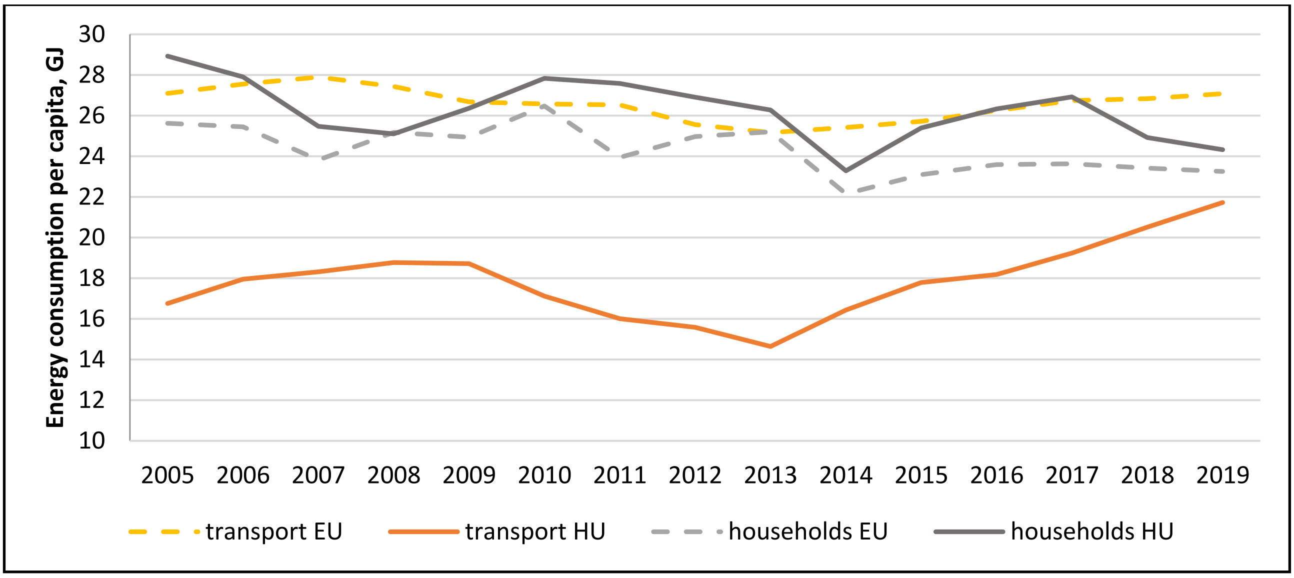

Figure 2: Household and transport energy consumption in Hungary and the EU27, 2005 – 2019. Source: Eurostat (2022a)

The increasing energy use in the transport sector might prevent Hungary from meeting its 2030 emission targets, so it is important that appropriate sufficiency policies are put in place to halt the rise in demand.

3

3. Sufficiency assumptions and policy options

A series of indicators were selected to represent the level of energy service consumption in the buildings and transport sectors to identify opportunities for policy interventions, relying on Marignac et al., (2021). These were approximated for Hungary based on 1) historic evolution of values compared to the EU average, 2) assumptions about the future perspectives of underlying influencing factors, and 3) region-specific sufficiency estimations found in the literature.

Sufficient levels targeted for 2050 in Hungary have been compiled from studies that have analysed the feasibility of decarbonisation pathways that would lead to global average temperature increases of up to 1.5° without the need for using large-scale carbon removal technologies (e.g. Grubler et al., 2018, Millward-Hopkins et al., 2020, Kuhnhenn et al., 2020). The indicators serve as a starting point for modelling scenarios including sufficiency assumptions, which, combined with sensitivity analysis, can help assess how policies targeting absolute demand reduction can contribute to reaching decarbonisation goals.

This section presents the sufficiency assumptions related to selected indicators in the buildings and transport sectors. It also proposes some policy instruments that can help trigger changes in consumption patterns.

3.1. Sufficiency assumptions in the residential buildings sector

Indicators related to demand for energy services in the buildings sector were selected based on available data for the most important sufficiency drivers. Table 1 lists the selected indicators, their values for the base year (2017), and the assumed sufficient target levels for 2050.

Table 1: Selected energy sufficiency indicators for the building sector

Indicator	Theoretical sufficiency target ranges for 2050 *	Hungary	
		Base year data (2017)	Assumed level for 2050
No of households (thousand)	-	4134	4031
Average household size	2 - 4[a]	2.37	2.3
Number of dwellings (thousand)	-	4651	4632
Average floor area per capita (m^2/capita)	30[b]-35[c]	37	35
Total floor area of dwellings (Mm^2)		381	324
Average size of new dwellings (m^2)	N/A	100	80.5
Average needs for hot water (kWh/person)	294-371[d]	893	520
Average needs for cooking (kWh/person)	N/A	337	220

**Sources of theoretical values: [a]Millward-Hopkins et al. (2020), [b]Grubler et al. (2018) [c]Bierwirth and Thomas et al. (2019), [d]négaWatt (2018)*

The number of Hungarian households increased until 2015, resting at around 4125 over the last three years (2018-2020) (Eurostat, 2021c). This happened despite a gradually declining population, resulting in falling **average household size** (Eurostat, 2021d). The same tendency can be observed in almost all countries across Europe as can be seen on Figure 3. We assume that increasing the popularity of cohabitation with targeted policies can stabilise this average at 2.3 by 2050.

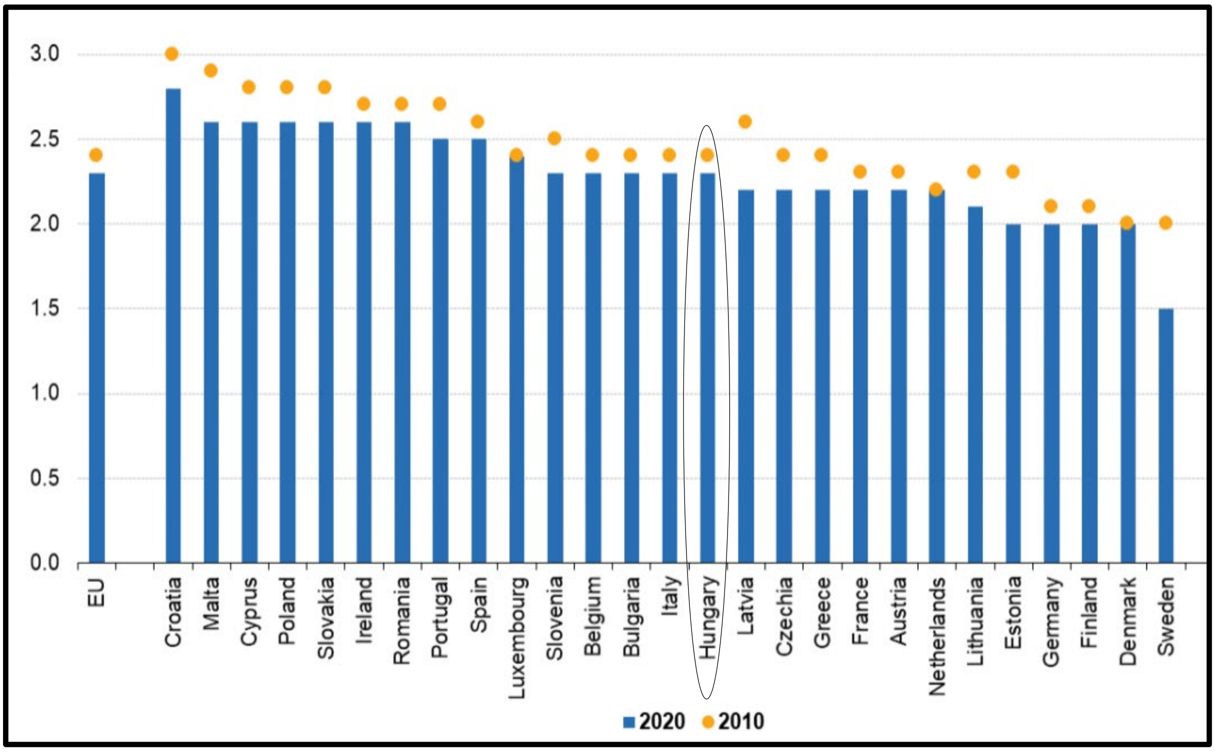

Figure 3: Change in household size in EU countries, 2010-2020. Source: EUROSTAT, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Average_number_of_persons_per_household_by_country,_in_2010_and_in_2020.png

The 12% vacancy rate in 2016 (KSH, 2016) will grow with new buildings exceeding the number of ceased buildings. There are several factors that can counter this trend, including single-households, utilization of empty dwellings for causes other than housing, or the demolition of buildings with disadvantaged features. Still, as the population will fall by 6% according to official estimates, and the average household size drops to 2.3 according to our expectations, we assume that the vacancy rate would increase to about 15% by 2050 given the current rates of newly built. Historical data shows that the number of ceased dwellings is smaller than the number of new buildings (KSH, 2021a), meaning the **number of dwellings** can be expected to grow. It can be offset by a higher demolition rate of ageing building stock for which renovation would not be feasible due to their bad energetic status and low market value (Erlt et al., 2021). This supports the notion that the growth in dwellings will plateau.

The **average floor area per capita** increased by 15% over the last 12 years, partially due to decreasing household size. It remains below Western European norms but is rising at a faster pace (Odyssee-Muree, 2021) and may result in approaching the level of Western European countries' per capita energy consumption. As Figure 4 shows, its value increased faster in Hungary and Lithuania than in France and Germany. The theoretical range for this indicator shows that there is a greater potential to reduce this value by restrictive regulatory measures (Grubler et al., 2018).

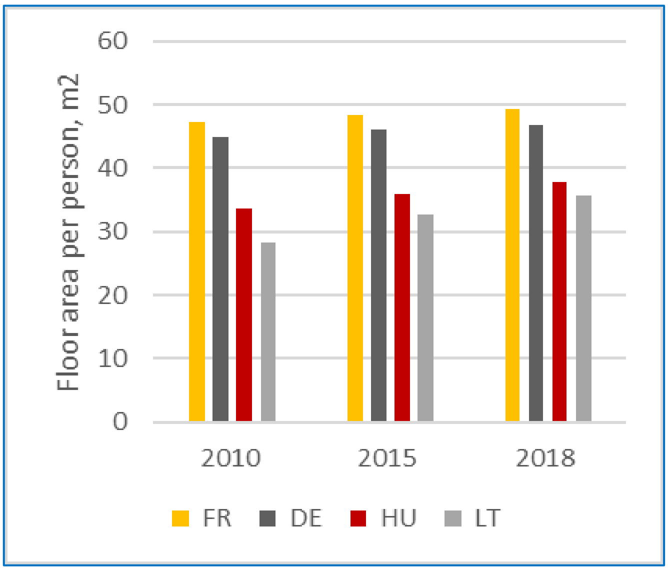

Figure 4: Floor area per person, 2010, 2015 and 2018 in Hungary, Lithuania, Germany and France, based on Odyssee-Mure, 2021

The rising **total floor area of dwellings** (Odyssee-Mure, 2021 and KSH, 2021a) can be offset by higher demolition rates of houses with no investment potential and better per capita utilization of used dwellings. Accounting for the decline in population, a 17% reduction in total floor area is assumed.

The **size of new dwellings** is dropped slightly in recent years (98 m^2 in 2020) possibly reflecting the increased per square meter prices in large cities which more than doubled in 2021 compared to 2015 (KSH, 2021b). We assume that new dwellings in 2050 will average 80,5 compared to 100 m2 in 2017.

The share of **hot water use** in total household energy consumption increased from 11.9% to 13.1% between 2017 and 2019, while the overall use decreased, and per capita values fluctuated (Eurostat, 2022b). Compared to 2017, we assume that energy use for hot water can reduce by 35%, albeit as Table 1 shows, there could be room for even larger reduction according to literature (négaWatt, 2019). Other factors like increased deployment of dishwasher appliances and higher efficiency of water heating systems also contribute to lower per capita energy use, although these would result from energy efficiency interventions rather than energy sufficiency improvements.

Total and per capita **cooking energy** has been relatively constant over the last five years (Eurostat, 2022b). Changes in consumption practices, such as increased dining in restaurants and food home delivery, might reduce the demand for the energy service.

BOX 1. Sufficiency policies in the residential building sector: good practices

Several policy tools promoting energy sufficiency in the building sector are applied already in Europe. One key approach to improve sufficiency is to promote co-living and increase the popularity of shared spaces to reduce the overall floor area of dwellings used for living. In Sweden, investors who build or renovate housing for elderly people can receive support to cover a certain part of construction costs, depending on the square meters and the number of planned residents. Extra support can be received for creating common spaces in the apartment buildings. (1)

Private investors found the business opportunity in creating buildings for co-living mostly in popular cities like New York or Berlin where the costs of housing are very high and there is a huge demand for this flexible and independent way of housing. Ollie (2), the all-inclusive co-living platform in New York is the city's first building designed for co-living for 426 residents, and Coconat (3) in Berlin is a complex multi-functional space for work and living, also offering opportunities for free-time and outdoor activities.

New family houses in rural areas might utilize previously non-occupied natural areas, and single-family houses consume too much space, building material, and energy in proportion to the number of people they are designed for (compared to the other alternatives). This is the reason why in Hamburg-Nord, a borough outside Hamburg, building new single-family houses are no longer allowed. In Germany 16 million of 42.5 million are single family houses and urban sprawling is becoming an issue. (4)

As space and water-heating are the areas which are responsible for the majority of the energy consumption of dwellings, policies targeting the reduction of energy usage for these two purposes could have very significant impact. According to literature, one of the most effective methods to induce change in consumer practices is to provide feedback on energy consumption, either indirectly, e.g., including historic and/or comparative consumption data on energy bills, or directly, via smart metering devices that measure and display information on energy use. This might result in 5-10% decrease in energy consumption (EEA, 2013, Bertoldi et al. 2016, Parker et al. 2016).

Subsidy programs for the installation of smart thermostats are available in several European countries (e.g., United Kingdom, Netherlands, Belgium, France, Germany, and Italy) in the form of investment support, tax deductions, vouchers discounts and administrative support, and can be even mandatory to install in case of the replacement of the heating system or upgrading the boilers to specific technologies (Netherlands, UK). In France and Italy, the smart thermostat must meet high quality standards to qualify for the support. (5)

(1) https://www.boverket.se/en/start/building-in-sweden/swedish-market/financing/support/
(2) https://ny.curbed.com/2017/5/8/15578746/long-island-city-co-living-ollie
(3) https://coconat-space.com/
(4) https://www.treehugger.com/should-single-family-houses-be-banned-5113017
(5) https://www.showhouse.co.uk/news/uk-leads-the-way-in-europe-for-supporting-smart-thermostats/

3.2. Sufficiency assumptions for passenger transport

Carbon emissions in the Hungarian transport sector have risen by 65% compared to 1990[2], mostly from road transport. (Eurostat, 2021a). Table 2 includes the base year indicators for the transport sector and sufficiency for 2050.

Table 2: Selected energy sufficiency indicators for the transport sector and assumed target levels for 2050

Indicator	Theoretical sufficiency target ranges for 2050*	Hungary	
		Base year data (2017)	Assumed level for 2050
No. of travellers per car (persons/vehicle)	2 – 3 [a, b, d]	1.5	1.7
Passenger km per capita	0.34[b]	0.22	0.3
Car use (pkm/capita)	17 935[a]	9 341	14 499
Buses and Coaches (pkm/capita)	1 077[1, b] – 7 526[1, c], 1 710[2, b] – 23 878[2, c]	1 415[1] 4 774[2]	988[1] 5 181[2]
Motorcycles and scooters (pkm/capita)	2 154[1, a], 3 420[2, a]	477[1] 1 392[2]	706[1] 2 897[2]
Rail (pkm/capita)	2 154[1, a], 3 420[2, a]	311[3] 789[4]	951[3] 2 521[4]
Air (pkm/capita)	581[c] – 1 841[b]	N.A.	1,000
Non-motorized transport (pkm/capita)	N.A.	N.A.	564

Note: [1]local, [2]long-distance, [3]tram/metro, [4]rail. Sources: [a]Millward-Hopkins et al. (2020), [b]Grubler et al. (2018), [c]Kuhnhenn et al. (2020), [d]négaWatt (2017)

The number of persons travelling in one car can have a significant effect on the passenger kilometres (pkm) travelled and thus the energy used for transportation. Unfortunately, no statistics are available on the actual average value of this indicator. We assume 1.5 persons per car based on aggregate statistics for pkm per car and the number of cars. Car-pooling and ridesharing are in the early stages in Hungary, while individual mobility is picking up. With this in mind, the potential for the indicator is 1.7 persons/car.

The **demand for passenger transport** (expressed in pkm/capita based on DG MOVE, 2021) is increasing, though still well below the sufficiency values proposed in the literature, between 16218 pkm/capita (Grubler et al., 2018) and 17935 pkm/capita (Millward-Hopkins et al., 2020). This figure is received as the sum of our estimations for the different transport modes, as described below.

Demand for car transport increased by more than 40% between 2005 and 2019 in Hungary (DG Move, 2021). Suggested sufficiency levels vary widely in literature but rather than assuming a bigger drop in pkm per capita a rearrangement of the shares of local and long-distance car use is expected. The total projected value for 2050 is 10904 pkm per capita assuming that as the total pkm per capita in long-distance journeys increases, car traffic in cities and smaller settlements will be mitigated through policies promoting public transport and active mobility.

The modal share of **bus transport** was 19.5% in 2019, the highest in the EU, which averaged 9.1% (DG Move, 2021). Demand is assumed to grow, led by local transportation, while long-distance couches will lose market

[2] Considering emissions excluding memo items and including international aviation.

share to the expanded railways. The volume of **rail passenger transport** has fallen 26% since 2005, with a modal share of 8%, closer to the EU average (DG Move, 2021). Railway can be made more attractive through improvements in service quality (availability, accessibility, reliability, comfort, interconnectedness) and a price level that keeps it competitive. Although infrastructure may be an important barrier to development, investments planned in coming years will contribute to enhancing the level of services (Hungarian Insider, 2021).

The charts shown in Figure 5 compare current and 2050 demand for buses and rail to the value ranges proposed in literature.

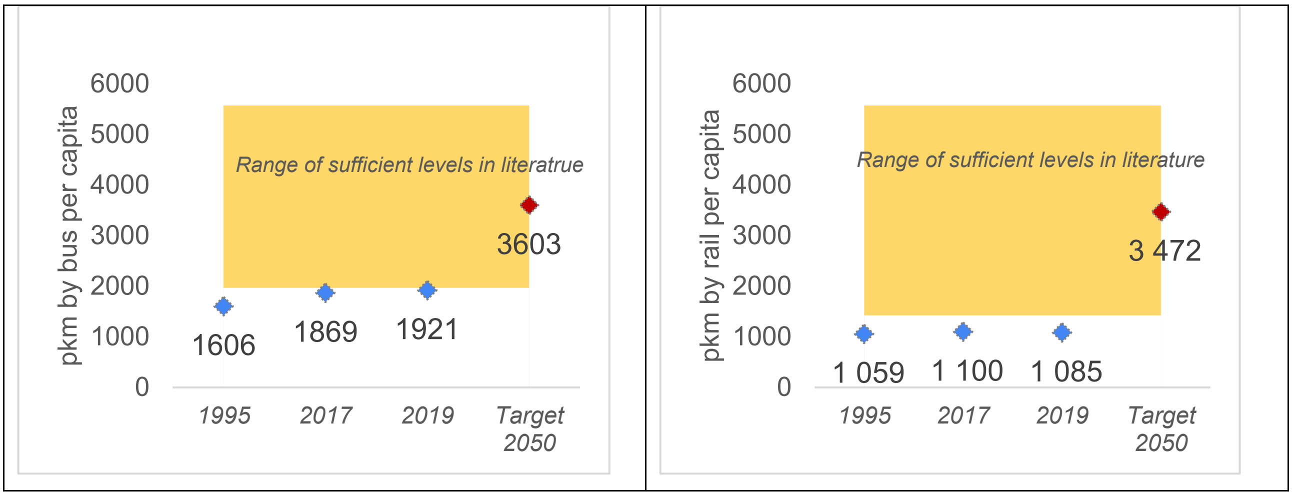

Figure 5: Sufficiency assumptions related to demand for bus and rail transport. Source of historic levels: DG Move (2021). Sufficiency range from literature: Grubler et al. (2018) and Millward-Hopkins et al. (2020)

The share of **transport by motorcycles and scooters** is minor with less than a 2% modal share in the EU (DG Move, 2021). No information on scooters is available and the 183 pkm per capita estimate is based on DG Move (2021) and the TRACCS database (TRACCS, 2013). Assuming that traffic mitigation policies will be applied to local transportation in coming decades, per capita demand for motorized two wheelers are expected to increase to 255 pkm by 2050.

Consistent data is not available for **air transport demand**. Statistics from different sources for 2017 range between 176 (Eurostat, 2022c) and 734 (KSH, 2021c). The demand for aviation is assumed to increase further and stabilise at around 1000 pkm/capita, including extra-EU aviation.

Data for **non-motorised** modes is also not published in national statistics. Only the Budapest Mobility Plan contains some information for Budapest in 2014. The current 9000 km of bike lanes across the country (KSH, 2019) should reach 15,000 km by 2030 (TTG Hungary, 2020). Bike sharing service is available in several large cities and Hungary is part of international bike routes (EuroVelo). However, increased car traffic makes biking less safe even in small settlements. Cleaner transport, adequate infrastructure and reduced traffic could increase the willingness of citizens to bike and walk. It is assumed that active modes can reduce motorised demand by an additional 564 pkm/capita by 2050.

BOX 2. Sufficiency policies in the transport sector - good practices

Reaching sufficiency goals in the transport sector can be promoted through market-based instruments (congestion fees, increased parking fees, road tolls), command and control policies (speed limits, vehicle access restrictions) and awareness raising. Urban design, investments in infrastructure and improving service quality also play very important roles in guiding the choices of passengers.

Congestion pricing has been adopted in several cities, including Singapore, London, Stockholm, and Gothenburg. In San Francisco, the price of parking adjusts in real-time with the change of demand, to avoid cruising (driving around to find free parking place) and parallel parking. (1) Singapore introduced vehicle quotas to limit the number of new cars that can enter traffic. Certificates are allocated annually in auctions and are valid for a 10-year period. (2) To decrease the number of cars on highways, high-occupancy vehicle (HOV) lanes are operated in the USA, the area of Houston. These lanes can be used by vehicles carrying two or more people, thus encouraging ridesharing, and using public transportation. In those periods when the capacity of HOV lanes is not fully utilized, other vehicles can use the lanes for an extra fee. (3)

Infrastructure can contribute significantly to reducing car use. The Copenhagen bicycle network is more than 400 kms with unidirectional, protected lanes, including superhighways. Special facilities (e.g. air pumps, tilted garbage bins) are available for cyclists, and Intelligent Transport System controlling traffic lights make cycling smoother. The share of car trips is only 30% in the city. (4)

In 2020, Germany increased the aviation tax for departing flights from Germany, which proportionally affects the price of shorter distance flights the most (up to 2500 km). The revenue is used to offset the value added tax on train tickets and incentivize a modal shift for short haul travel. (5)

Some large cities, including Kajaani, Nuremberg, Strasbourg, and Oxford redesigned road systems to reclaim space from car traffic and increase green pedestrian areas. (6) Vienna recently decided to follow the example of Barcelona in restructuring the typical road network into 'superblocks' which surround interior areas reserved for pedestrians. The speed of unavoidable transport to serve basic services and residents is lowered to 10 km/h. (7) The increased density and convenience of public transport results in high public acceptance with improvement in air quality and reduced traffic (IEA, 2021). Green areas can contribute to the alleviation of adverse climate effects as well (e.g. heat islands).

Solutions limiting the excessive spatial expansion of cities into land area outside of city boundaries (urban sprawl) can also reduce individual car use in less dense residential areas. Urban consolidation policies applied in Australia, New Zealand and North America aim to reverse the expansion of cities and make use of existing building areas and infrastructures within the urban boundaries. Urban development plans focus not only on sustainability but also liveability, walkability and proximity to schools, workplaces, goods and services (cafes, restaurants, shops) and well-designed public spaces. (Haarhoff et al. 2016).

(1) https://www.wri.org/insights/strategies-sustainable-cities-demystifying-transport-demand-management
(2) https://www.valuechampion.sg/basics-of-coe
(3) https://www.transportation.gov/mission/health/High-Occupancy-Vehicle-Lanes
(4) https://eu.boell.org/en/cycling-copenhagen-the-making-of-a-bike-friendly-city
(5) https://www.transportenvironment.org/news/german-rail-fares-go-down-part-climate-measures
(6) https://ec.europa.eu/environment/pubs/pdf/streets_people.pdf
(7) *http://bcnecologia.net/en/conceptual-model/superblocks*

4

4. Insights from modelling

This chapter presents the first results of sufficiency-related modelling using the HU-TIMES model. The HU-TIMES model is based on deterministic, dynamic linear partial equilibrium mathematical optimization method, which considers all costs related to the whole energy sector value chain. The model covers the period between 2016 and 2050 using the NECP's WAM (with additional measures) scenario as a baseline (similarly to the projections of the Hungarian LTS) to estimate the possible impacts of reaching sufficient consumption levels associated with the selected indicators.

Before presenting the model results, two important points should be noted:

1. As the research project did not initially cover modelling, minimal analysis was possible at this stage of the research. For this reason, the few indicators that could be easily fitted into the model were selected and analysed.
2. The results of the model run are presented for 2050, the year for which the HU TIMES model assumes net zero GHG emissions under current settings. Since the intermediate years between 2017 and 2050 have not been analysed yet, no results can be presented for the emission reductions saved, only for energy demand reductions.

Key model parameters were exogenously changed based on the above presented estimates of selected indicators. Although this simple approach cannot capture agent decision making, it provides a first insight into the possible scale of reductions sufficiency related policy instruments could facilitate.

4.1. Residential buildings

In the residential building sector, the effect of three indicators was investigated, assuming linear change in the variables until they reach their sufficiency levels targeted for 2050 (see Table 1):

- per capita energy demand for cooking (COOKING scenario)
- per capita energy demand for hot water (HOT WATER DEMAND scenario), and
- the average floor area per person in new buildings (AVG FLOOR AREA scenario).

The combination of the three above cases were also analysed (RSD COMBINED scenario).

From among these indicators, the integration of reduced per capita floor area posed a challenge because the required reduction could not be accomplished by only reducing the size of new dwellings. Only one of the newly built dwelling categories featured higher floor area per person than the target level (35 m^2). Therefore, the yearly changes in the floor area of the total housing stock were too small and the targeted sufficiency level could not be fully analysed. Measures like the promotion of co-habitation can further decrease the average square meters of the total housing stock and will be the subject of later analysis. The indicator values reached by 2050 in the scenarios are shown in Table 3.

Table 3: Scenarios related to the residential building sector

	REF	COOKING	HOT WATER DEMAND	AVG FLOOR AREA	RSD COMBINED
Energy consumption for cooking per person (kWh/capita/year), 2050	333	220	333	333	220
Annual hot water energy demand per person (kWh/capita/year), 2050	770	770	520	770	520
Average floor area per person in new family and terraced apartments over 120 m^2 (m^2/capita), 2050	69	69	69	35	35

Incorporating the target values for the selected indicators resulted in different levels of energy consumption reduction. In total 6 PJ of energy can be saved by 2050 combining all three measures. This corresponds to an 8.5% decline in energy consumption compared to the reference scenario.

Each scenario reaches nearly zero emissions by 2050 and the selected sufficiency measures result energy savings, meaning less required investments in new power capacities. The annual additional savings from the analysed sufficiency measures vary between EUR 20 and 247 million in the different scenarios, with the largest savings in hot water demand.

4.2. Passenger transport

The analysis in the transport sector assumed linear per capita demand reduction for

- car transport (CAR USE scenario) and for
- total passenger transport (TOTAL DEMAND scenario) as indicators,

reaching their sufficient levels by 2050 (Table 4). The combined effect of the sufficient values for the two indicators was also checked (TRN COMBINED).

Table 4: Scenarios related to the passenger transport sector

	REF	CAR USE	TOTAL DEMAND	TRN COMBINED
Demand for car transport, short distance (pkm/capita/year), 2050	1340-3718*	988	1340-3718	988
Demand for car transport, long distance (pkm/capita/year), 2050	6420-16200*	5181	6420-16200	5181
Demand for land transport, short distance (pkm/capita/year), 2050	3755	3755	2900	2900
Demand for land transport, long distance (pkm/capita/year), 2050	16200	16200	10600	10600

Note: the ranges in the demand for car transport in the reference case are due to the current settings in the model allowing for modal shift.

Sufficiency measures influencing these two demand levels result in more significant reductions in energy consumption compared to buildings. Lower car use results in a 5 PJ savings (2.6% decrease) from a modal shift between electric cars and electric and hydrogen fuelled buses and trains in both the short- and long-distance personal transport segments (CAR USE scenario). Although car electricity use declines, electricity inputs for hydrogen offsets much of the achieved energy savings, as can be seen on Figure 6.

Under the TOTAL DEMAND scenario, energy consumption in the transport sector drops 18 PJ compared to the reference case, resulting in both electricity and hydrogen savings. The combined effect of these two sufficiency measures is an overall decline of 22.3 PJ (TRN COMBINED) resulting from lower electricity usage

(22.3 PJ), lower amounts of gasoline and biofuel use (0.8 PJ) and higher hydrogen consumption (0.8 PJ) offsetting some of the reduction.

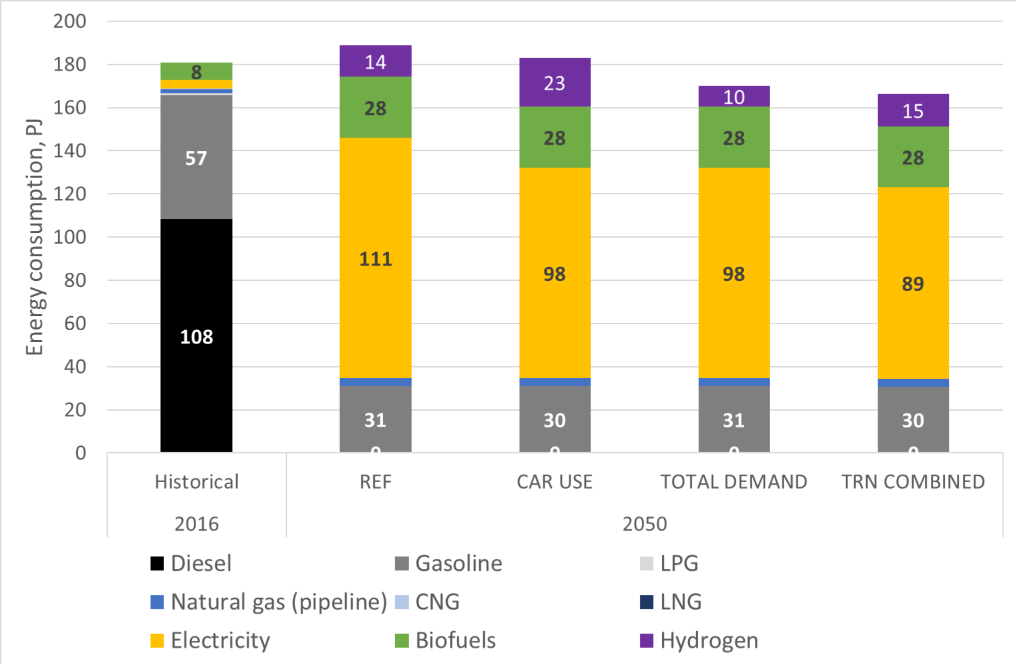

Figure 6: Energy consumption by energy carriers in the transport sector in 2050. Note: REF – reference scenario, TRN Combined – combination of the sufficiency measures for the reduced car use and the reduction in total demand for passenger transport.

As the shift to clean buses and trains increases the demand for hydrogen which requires clean electricity to produce, solar power plant capacities remain unchanged in the CAR USE scenario. However, the sufficiency measures targeting total transport demand reduction (TOTAL DEMAND) can lead to quite significant electricity savings, requiring less production capacity. The annual cost savings from avoided investments in capacities are EUR 800 million (CAR USE), EUR 1105 million (TOTAL DEMAND), and EUR 1800 million in case of TRN COMBINED. This shows that modal change alone might not achieve energy-system cost savings in 2050 without absolute demand reduction.

5

5. Further impacts of energy sufficiency

Energy sufficiency has multiple benefits, most of which overlap with the positive impacts of energy efficiency. Besides the effects discussed in the previous chapter, there are other direct co-benefits, such as the avoidance of air, soil and water pollution which can be relatively easily estimated but are difficult to quantify financially. As regards energy systems, in addition to avoiding investments in additional generating plants, substantial savings can be achieved on transmission capacity and the related infrastructure. Consumer energy bills and fuel costs decline, and savings can also be made on the lower purchase (or rental) price of smaller or shared dwellings, shared appliances, smaller vehicles, or the decision not to own a car.

However, energy users might need to sacrifice daily comforts (for example door-to-door travelling by car, privacy in unshared rooms). These are difficult to express in monetary terms. On the other hand, as a precondition for achieving sufficiency policy goals, other types of investments are needed, e.g. in the case of transport, achieving lower private car use assumes the commissioning of infrastructure (safe and extended bicycle paths, railways, public transport improvements, redesigned road structures, etc.) and the wider availability of high quality public transport services.

Furthermore, energy savings increase energy security and mitigate energy price volatility. This contributes to the resilience of societies, particularly relevant in the current geopolitical context. Changes in consumption patterns, such as the development of the sharing economy, can strengthen the sense of commonality and lead to more interaction among people. Reduced fossil energy consumption will have a positive impact on GHG emissions, air pollution, noise levels and associated premature deaths, improving the health of people and the living environment, and thus lowering public expenditures on health and environment protection.

However, energy savings can also lead to direct and indirect rebound effects, which are important to include in the assessment of policy options. Rebound is unavoidable, especially with lower income households, since many have not reached the satisfactory level of energy consumption. Current energy poverty policies focus on reducing energy prices rather than structural changes towards more efficiency and sufficiency. A change in the current approach can mitigate the rebound effect issue (Sorrell et al. 2020).

It is important that governments take into account all relevant costs and benefits, including not only economic but also social and environmental impacts, when defining national policy instruments. Scenario modelling can evaluate different policy options by incorporating such value estimations.

Summary and recommendations

Sufficiency helps mitigating the rising energy consumption thus avoiding the possible offset of energy efficiency achievements. It contributes to decreasing the reliance on imported fossil fuels, while also lowering energy system investment needs related to electrification.

At present, some consumption patterns in Hungary (e.g., lower level of per capita floor area, higher modal share of public transportation) are more sustainable compared to the EU average but are fast approaching it. Sufficiency measures can not only contribute to reduced energy consumption in the longer term but can also help keep consumption levels down in the short term, shaving future peak energy demand.

In the analysed sectors, policies targeting demand reduction can result in sizable cost savings from lower energy consumption, lower number of vehicles in operation, and avoided investments in RES-E capacity. The effect of reaching sufficient levels for the selected, limited number of indicators could save 8,5% and 12% of the energy used in the residential buildings and passenger transport sectors. There are additional, hard-to-quantify impacts, such as the corresponding personal costs and benefits e.g. the cost of shifting to public transport or active modes and benefits from lower traffic and cleaner air, etc. Infrastructure costs will also be important to consider, as the deployment of energy sufficiency measures is largely determined by consumer behaviour, which is significantly influenced by the availability of infrastructure.

The current modelling framework could be expanded to include a wider range of sufficiency measures and examine intervening years between 2020 and 2050. This analysis incorporated sufficiency measures that have already met climate objectives, leaving 2050 results short of reflecting the cumulative emission savings. Analysing the impact of energy sufficiency measures on a shorter time horizon would also be useful to evaluate the competitiveness of sufficiency with other policy options available during the revision of the Hungarian NECP to deliver 'FIT for 55' European Green Deal targets. To provide a complete picture of associated costs and benefits, the modelling could be supplemented with macro modelling (i.e., using general equilibrium models simultaneously) to complement the range of decarbonisation polices considered in the initial modelling analysis.

The sufficiency assumptions determined for the selected indicators in this analysis can serve as a starting point for modelling national trajectories incorporating sufficiency measures, while empirical studies on recently introduced interventions in other countries will help to further refine assumptions. A systematic integration of the energy sufficiency concept in all sectors of the economy could help to achieve notable reductions in energy demand.

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