Innovációs és Technológiai Minisztérium

National Clean Development Strategy 2020-2050 Executive Summary

ITM
FELADATUNK A JÖVŐ

Foreword

In the Carpathian Basin in Hungary, we are experiencing the negative impacts of climate change—the most significant environmental, economic, and social problem of our time. The world we leave to our children and grandchildren solely depends on us. Therefore, instead of empty words, it is time to act. Hungary and the Hungarian government are committed to leading the way and choosing the path of action.

In January 2020, we set definite strategic targets in the field of climate change and environmental protection. We adopted the first *Climate Change Action Plan* that contains concrete measures for achieving the medium- and long-term goals of the *Second National Climate Change Strategy*. The *National Energy and Climate Plan* for the period up to 2030 and the new *National Energy Strategy* both contain clear objectives for the medium term. In the above documents, we pledge to make 90% of our electricity production carbon-free by 2030. Besides reducing greenhouse gas emissions, we are also committed to strengthening energy security, reinforcing climate protection, and expanding economic development. Specific interventions of the *Climate and Nature Protection Action Plan*, adopted in 2020, also support environmental protection targets. The *Climate Protection Act*, also adopted last year, sets the goal to achieve climate neutrality by 2050. Finally, the *National Clean Development Strategy*, presented herewith outlines the pathways toward climate neutrality and confirms that the Hungarian government is taking concrete actions to combat climate change. With this background, Hungary is clearly choosing a clean future that follows the path of climate protection, energy sovereignty, and green economic development.

In the field of climate protection, Hungary pursues a reasonable and responsible policy. Climate neutrality must be achieved in a way that ensures the security of supply, a just transition, and economic development. The government insists that primarily the biggest polluters need to pay the cost of the transition and that increased utility costs for families must be avoided. Achieving the transition will not be an easy task. The following 30 years toward climate neutrality will be challenging since we are trying to reach a goal with some uncertainty along the way. What this transition means to our everyday lives is not yet fully clear, but we must stay on track with our common climate goal lighting the way.

Our country starts off from a favorable position on the journey toward climate neutrality. Hungary’s performance is outstanding compared to other European and global emission levels. Since 2000, Hungary is one of the few countries that has managed to increase its GDP while reducing CO_2 emissions and energy consumption. The Hungarian economy has, in fact, been able to produce a unit of GDP with 24% less greenhouse gas emissions when compared to 2010 levels. The *National Clean Development Strategy* serves as a torch on the road toward a cleaner future, economic development, and improved social welfare.

Prof. Dr. László Palkovics
Minister for Innovation and Technology

Executive Summary

Our country has expressed efforts to support achieving climate neutrality by 2050 with the adoption of Act no. XLIV of 2020 on Climate Protection. The National Clean Development Strategy (NCDS or Strategy) outlines a 30-year vision of socioeconomic and technological development pathways. Hungary's long-term Strategy will help reach climate neutrality targets while focusing on the well-being of the Hungarian people and ensuring the protection of natural assets and economic development.

Hungary starts this endeavor from a strong position, being among the few countries since 1990 where the gross domestic product (GDP) has increased while CO_2 emissions decreased, by 33%. This confirms that climate protection, economic growth, and energy security are not necessarily conflicting objectives. By this, the long-term vision contributes to the United Nations (UN) Sustainable Development Goals (SDGs) by i) "Providing affordable, reliable, sustainable and modern energy for everyone," ii) "Creating sustainable consumption and production patterns," and iii) "Fighting climate change and its impacts with urgent response measures."

The NCDS was based on a wide stakeholder consultation process.

To outline the long-term trajectory, an integrated modeling approach was used to explore the specificities of the sectors as well as the system-wide and cross-sectoral dynamics of the decarbonization process. The development of projections was helped by applying two models:

1) The **Green Economy Model** (GEM) is an intersectoral model that uses system dynamics as its foundation. This methodology supports the estimation of the macroeconomic outcomes of decarbonization, including the economic evaluation of several social and environmental externalities in addition to changes in the labor market.
2) The **HU-TIMES model** was used iteratively with the GEM to simulate the energy sector and to outline the emission routes of the energy and industrial sectors. TIMES is a bottom-up, partial equilibrium optimization model used to analyze the different pathways of energy flow within the energy subsectors.

Three main scenarios for greenhouse gas (GHG) emissions up to 2050 have been developed and analyzed:

1) **Business-as-usual (BAU) scenario:** The emission trajectory of the BAU scenario follows current trends, assuming that all existing sectoral policy strategies and measures remain in effect, and that there will be no new interventions.

2) **Late action (LA) climate neutrality scenario:** This scenario aims to reduce emissions in the energy sector at a delayed and slower pace until 2045, and then with an increased effort until 2050. This allows the lower cost levels of low and zero emission technologies to be exploited. The scenario assumes that, in line with the targets set in the climate act, the final energy consumption could reach a maximum of 785 petajoules (PJ) in 2030, with the share of renewable energy increasing to at least 21%. After 2030, non-waste sectors will be on the lowest cost trajectory toward climate neutrality until 2050, which will result in accelerated emission reductions by 2050, due to the postponement of investments pending on a decrease in technology costs.

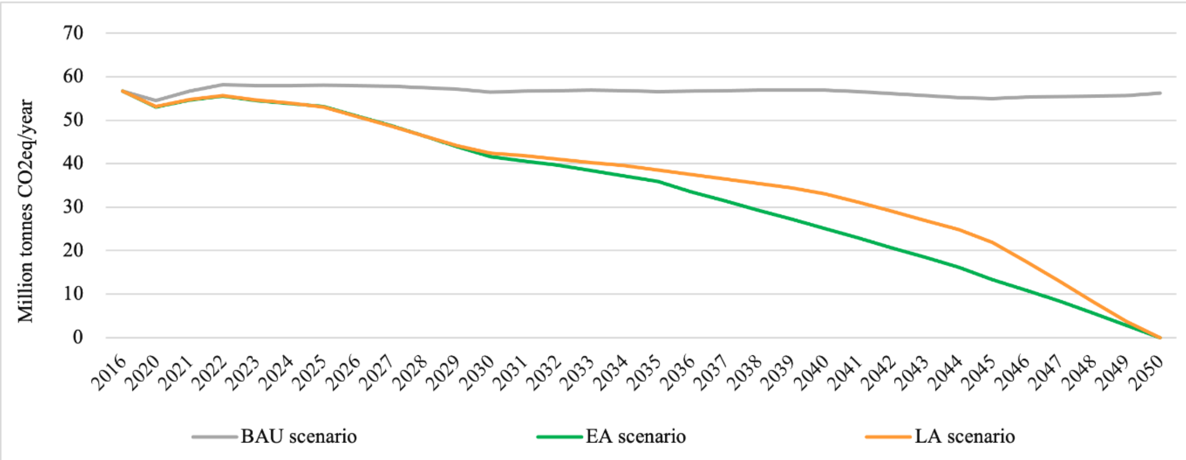
3) **Early action (EA) climate neutrality scenario:** the EA approach envisages achieving climate neutrality by 2050 while considering the short- and medium-term benefits of job creation and a reduction of environmental externalities, the economic potential of the first

mover, improved productivity, and higher GDP growth. The EA scenario assumes that Hungary's final energy consumption in 2030 will be a maximum of 734 PJ, and that renewable energy penetration will reach 27%. The emission reduction trajectories for industry; land-use, land-use change and forestry (LULUCF); waste management; and agriculture are the same as in the LA scenario. Between 2030 and 2050, emissions will follow a linear trajectory to reach net zero emissions.

In both the LA and EA scenarios, carbon capture, utilization, and storage (CCUS) technologies will become commercially viable in the energy and industrial sectors after 2030.

According to the modeling results, GHG emissions in the BAU scenario will decrease to only 56 million tons of CO_2 equivalent (CO_2eq)/year, from 2019 levels. **Therefore, a considerably stronger effort will be needed to achieve the 2050 climate neutrality target[1] than the policies and measures currently in effect.**

According to both climate neutrality scenarios, net zero emissions will be reached by mid-century. However, the clean energy transition will vary based on different assumptions, and the generation of socioeconomic benefits will differ in their development pathways (Figure 1).



Source: Eurostat data, projection based on own modeling results

Figure 1 – Expected change of total annual net GHG emissions for the whole economy under the three scenarios examined (CO_2eq/year)

During its December 10–11, 2020 session, the European Council decided to increase GHG reduction targets to 55% by 2030.[2] **Both climate neutrality scenarios of this Strategy fulfill this increased target.**

The emission reductions of the two scenarios will diverge during the mid-2020s, with a difference exceeding 800,000 tons of CO_2eq by 2030.

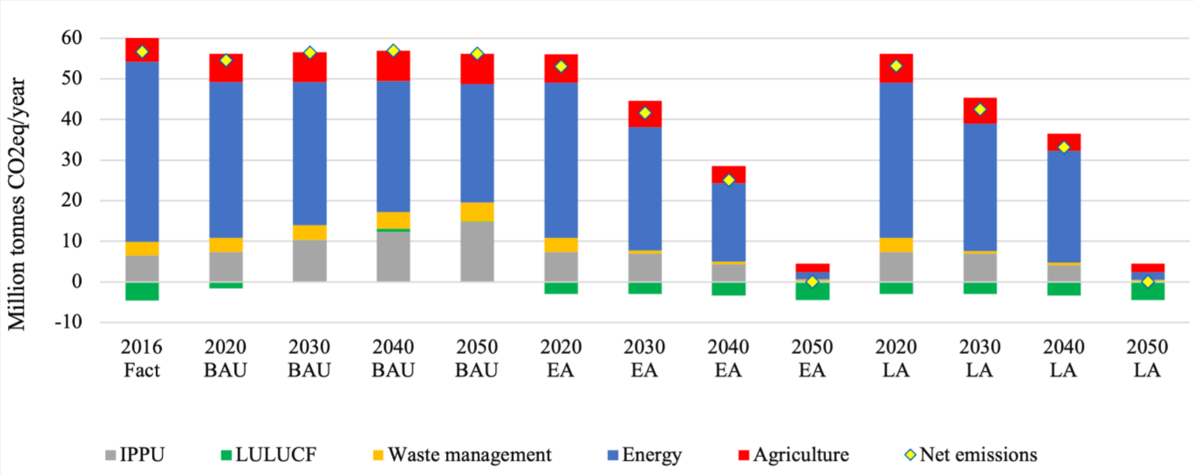
The EA scenario will require stronger mitigation efforts, however the increased investments will boost country’s economic growth. The end-user demand will increase including the demand for traveling and buying household appliances.

[1] Domestic emissions and absorption will be in balance by 2050

[2] European Council meeting (10 and 11 December 2020) – Conclusions Brussels, 11 December 2020 (OR. en) EUCO 22/20, CO EUR 17, CONCL 8

The **EA scenario follows a more gradual emission reduction pathway** since the investments serving the energy transition and decarbonization are carried out sooner. Furthermore, the EA scenario is characterized by an accelerated larger-scale "clean" electrification and decarbonization of the electricity system.

The sectoral distribution of GHG emission reductions under different scenarios is illustrated in Figure 2.



Source: Eurostat data, projection based on own modeling results

Figure 2 – Sectoral distribution of net GHG emissions for the three scenarios ($CO_2eq/year$)

The emissions of the energy sector, being the largest GHG-emitting sector, will fall under 1.7 million tons of $CO_2eq/year$ according to the EA scenario. The LA scenario also forecasts emissions under 2 million tons of $CO_2eq/year$ (the expected emissions is 1.9 million tons of $CO_2eq/year$) by mid-century. In contrast, according to the BAU scenario, the emissions of the energy sector can only be decreased to 29 million tons of $CO_2eq/year$ with already adopted and applied interventions and policies.

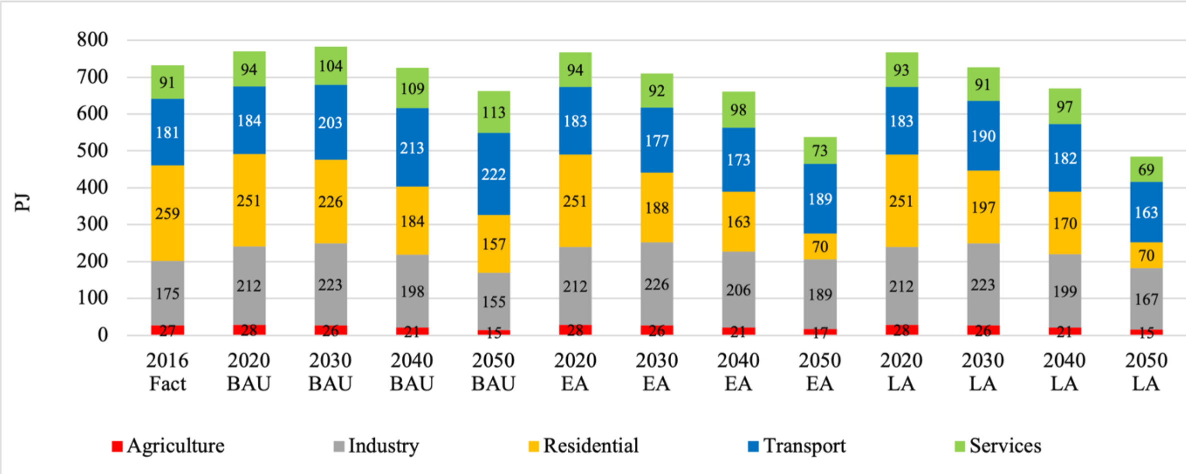
In the EA scenario, sectoral emissions after 2030 are consistently lower than in the LA scenario. Emissions from industrial processes are higher toward the end of the period, which can be explained by the larger-scale economic growth and the increase in industrial productivity provided by the EA scenario.

Natural sink capacities will be expanded to balance out the remaining emissions in 2050. It is forecasted in the EA and LA scenarios that 4.5 million tons of $CO_2eq/year$ will be naturally absorbed, mainly due to the increasing forest coverage. Without additional interventions, however (according to the BAU scenario), forests will become net emitters (the GHG emissions of forests can reach a net 140,000–145,000 tons of $CO_2eq/year$).

The energy sector - including the energy supply and the energy consumption of the industry and transport sectors and others (such as tertiary or residential sectors) - **has the most significant role in reducing emissions.** This is because the energy sector accounts for 70% of total emissions and has the largest potential to reduce emissions (Figure 3). Consequently, **drastic changes are needed to decarbonize Hungary's energy supply system** (including energy production capacities) **and to enable the end-user side to reduce energy consumption and utilize clean energy technologies.**

Under the BAU scenario, the final energy consumption between 2016 and 2050 can be reduced from 733 PJ to 662 PJ. However, this would not be enough to reach climate neutrality by 2050. **The final energy consumption is forecasted to be 538 PJ and 484 PJ by 2050 according to the EA and LA scenarios, respectively.** In the former case, the higher energy consumption is explained by the larger-scale economic growth indicated by the EA scenario.

Looking at a sectoral distribution (Figure 3), **the households (residential) sector has the largest energy saving potential.**



Source: Eurostat data, projection based on HU-TIMES modeling results

Figure 3 – Composition of final energy consumption by sector in each scenario, 2016–2050 (PJ)[3]

Even the BAU scenario shows reductions in household energy consumption due to the significantly lower energy use of new household appliances, newly built and energy-efficient buildings, and renovations and retrofits to existing buildings. As a result, the energy consumption of nearly 260 PJ in 2016 will drop under 160 PJ by 2050 in the BAU scenario. This value will be even considerably lower in the climate neutrality scenarios, where the household energy consumption will decrease to approximately 70 PJ by 2050.

The energy consumption of the industrial sector is different in the three examined scenarios. In the BAU scenario, the increase in energy consumption is dominant due to the higher GDP, which will be compensated by energy efficiency investments. A consistently decreasing trend can be observed from 2030 onward. **Overall, the two climate neutrality scenarios show a decreasing trend; however, some increase is forecasted until 2030. After 2030, energy consumption in the EA scenario will decrease at a lower rate than in the LA scenario.** This is explained by higher GDP growth and therefore higher industrial productivity in the EA scenario.

The service and transport sectors follow similar trajectories in the climate neutrality scenarios. In the BAU scenario, the energy consumption of both sectors slightly increases. The two climate neutrality scenarios show a 10–20% reduction compared to the current levels, due to energy efficiency investments and the use of more efficient fuels.

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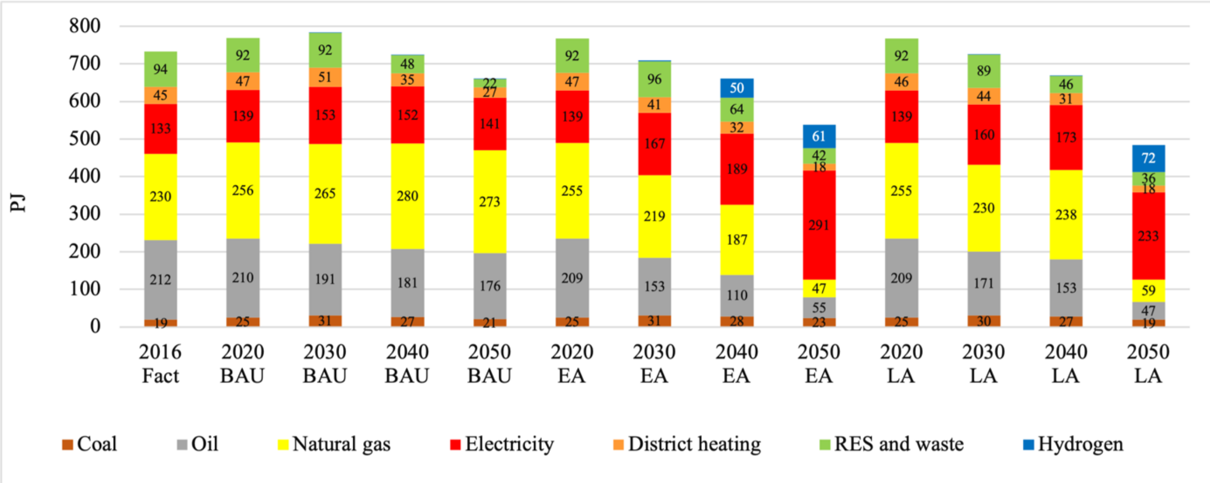
[3] Explanation: based on experts' judgment, the year 2016 was chosen as the baseline year for the HU-TIMES model

The fuel mix of the final energy consumption (Figure 4) **must change significantly to reach the 2050 climate neutrality target.** There is no significant shift of the fuel mix in the BAU scenario; however, the share of natural gas is increasing, which overshadows the renewable energy sources.



Source: Eurostat data, projection based on own modeling results

Figure 4 – Final energy consumption fuel composition in each scenario, 2016–2050 (PJ)

The most significant change caused by the two climate neutrality scenarios is due to large-scale electrification. For the EA scenario, the use of electricity accounts for over half of the total energy consumption, which is similar to the rate of the LA scenario.

As a result of electrification in the transport sector, **the consumption of petroleum will decrease drastically**—to nearly a quarter of the current level—by 2050 in the climate neutrality scenarios. **The other significant change, which will start in the 2040s, is the decline in natural gas consumption** and the complete disappearance thereof in some sectors. Natural gas is partly replaced by hydrogen, mainly in the transport and industrial sectors. By 2040, **hydrogen will already play an important role in both climate neutrality scenarios.** By 2050, hydrogen will account for 11% and 15% of final energy consumption in the EA and LA scenarios, respectively.

To achieve net zero GHG emissions by 2050, based on currently available technological developments, **efforts are needed in the following areas:**

1) **Energy efficiency improvement** in all fields of the national economy and establishment of a circular economy;
2) **Electrification** in all areas of the economy, based on domestic nuclear and renewable energy sources;
3) **Application of CCUS technologies** in the energy sector and in high emitting industrial facilities;
4) **Use of hydrogen and upscaling of the related hydrogen technologies;**
5) **Sustainable utilization of bioenergy (within limits);**
6) **Sustainable, modern, and innovative agriculture;**

7) **Increase in natural sink capacities, mainly through the absorption of CO_2 by forests and maintaining forests as the most potential natural sinks as well as rethinking economic and financial incentives for forestry**; and
8) **Research, development, and innovation** as well as corresponding education and training programs.

Main directions for interventions:

- Support is needed for residential **energy saving**.
- Acceleration and expansion of **energy efficiency** investments are necessary, especially in the residential and commercial sectors.
- Significant investments will be needed to **electrify** the economy, especially in the transport, residential, and commercial sectors. One of the main conditions for the electrification of the economy is the modernization and climate-friendly transformation of the energy sector.
- Further investment will be needed in the **development of CCUS technology**, **increasing the utilization of renewable energy and energy storage systems**. Given carbon phase-out efforts, new investment in fossil fuel-based technologies and industries runs the risk of rapidly depreciating assets (i.e. stranded assets).
- Besides more efficient **industrial processes and product use** (IPPU), CCUS technologies and alternatives to replace fossil energy sources (as raw material) are needed in the future. These alternatives can be carbon-free or low-carbon hydrogen and its derivatives as well as alternative biological raw materials. Furthermore, raising public awareness to shape consumption patterns and promoting the transition to a circular economy will have a significant positive impact on industrial emissions.
- Besides the electrification of the **transport** sector, expanding the application of **second-generation (or advanced) biofuels** and hydrogen, as well as the more efficient usage of fuels and the gradual decrease in using liquefied petroleum gas (LPG) on the market, will contribute to decarbonizing and modernizing the sector.
- In **agriculture**, a reduction in fertilizer use; a more efficient use of organic fertilizers; and a wider application of precision farming, automatization, and digitalization will be needed. Moreover, investments targeting feeding, irrigation, and energy efficiency are key. The **LULUCF** sector will require significant investments to enhance net CO_2 capture (sink capacities) after 2030. This will be especially needed for measures that improve forest adaptation, reduce logging in the medium term, and increase afforestation efforts in the long term. For sustainable forestry, the maintenance of stocks with the most optimal CO_2 equilibrium and business model (regarding area and age structure) needs to be emphasized. Furthermore, interventions should support maintaining and developing forests while protecting their natural levels despite climate change impacts.
- The **waste sector** will require significant investments to drastically reduce landfilling. Reducing landfills, diverging waste flows, and improving waste treatment methods account for around 90% of the emission reductions of the sector. Further investments will be needed to reduce the amount of industrial waste, to improve municipal waste treatment, and to prevent waste in the first place. To reduce emissions in waste management, additional investments are necessary in other sectors (e.g., in the transport sector because of waste transport, or in the energy sector because of nonrecyclable waste combustion).

- **Research, development, and innovation** will be one of the main pillars of achieving our energy and climate goals. Through the research development and further improvement of new technologies and processes, as well as their market introduction, a degree of cost reduction can be achieved to greatly help the spread of clean technologies.
- The **education and (re)training** of professionals capable of developing and/or applying new technologies and processes is also crucial to reach climate neutrality.

Cost-benefit analysis

In order to achieve climate neutrality by 2050, significant investments will be required in the upcoming decades. However **the possible benefits of decarbonizing the national economy in the medium and long term will exceed these costs** (Table 1).

According to the EA scenario, the investment costs will be HUF 24.7 billion[4] higher compared to the BAU scenario. Conversely, the additional cost according to the LA scenario is HUF 13.7 billion. The difference between the two scenarios originates in the energy sector. The additional annual investment need accounts for 4.8% of the GDP in the EA scenario.

Based on the analysis, the **full decarbonization of the Hungarian economy will also generate significant avoided costs and added economic benefits.** Assessing the period up to 2050, the value of avoided costs and added benefits are observed to exceed the investment costs. Moreover, these avoided costs and additional benefits will continue to occur well after 2050; however, this is not discussed in this document. **Considering avoided costs and added benefits, the EA scenario is the most cost-effective scenario.**

Investing in the green transition brings macroeconomic benefits that lead to **significant boost in economic growth and create additional green jobs compared to the BAU scenario**.

Based on the EA scenario, the cumulated surplus GDP amounts to approximately HUF 19.8 billion—but only HUF 11.2 billion based on the LA scenario (Table 1, Figure 5). The **government revenues are forecasted to increase by HUF 11.1 billion cumulatively in the EA scenario** (while the LA scenario shows a growth of HUF 6.2 billion).

	EA scenario 2020-2030	LA scenario 2020-2030	EA scenario 2020-2050	LA scenario 2020-2050
Investment costs – billion HUF				
Agriculture	82	82	745	745
Waste management	851	852	480	476
IPPU	79	80	129	131
Energy	1 297	644	22 391	11 352
LULUCF	35	35	964	96 473
Total investment costs	**2 344**	**1 693**	**24 709**	**13 668**
Avoided costs - billion HUF				
Material	693	685	2 393	556
Avoided energy cost	*638*	*630*	*2 142*	*305*
Avoided fertilizer cost	*56*	*56*	*251*	*251*

[4] 1 EUR = 350 HUF

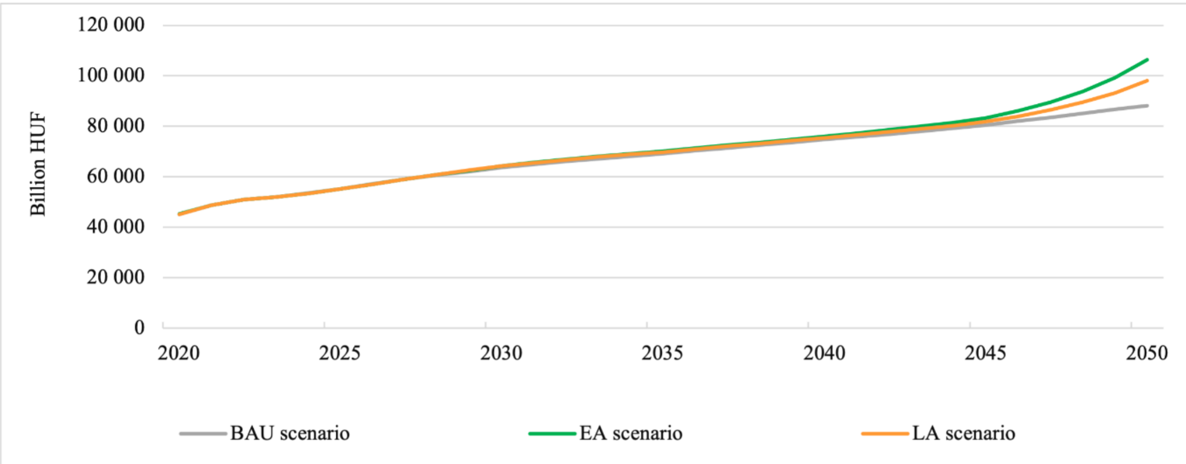
Nonmaterial	527	279	4 993	3 441
Avoided social cost of carbon	*487*	*480*	*2 604*	*2 269*
Transport-related negative externalities	*40*	*-200*	*2 389*	*1172*
Total avoided costs	**1 221**	**964**	**7 387**	**3 997**
Added benefits – billion HUF				
Real GDP	**582**	**482**	**19 783**	**11 170**
Government revenue	**246**	**215**	**11 142**	**6 200**
Additional job creation – number of jobs				
Total net new jobs	16 283	17 962	**182 566**	**123 690**
Indirect employment creation	10 340	11 349	64 983	60 678
Direct employment creation	5 943	6 613	117 583	63 012

Source: own modeling result

Table 1 – Cost-benefit analysis for the periods 2020–2030 and 2020–2050 (additional costs and benefits compared to the BAU scenario)

According to the analysis, economic growth will be considerably higher after 2028. By 2034, the GDP and GDP growth trajectory will follow a similar path for the BAU and EA scenarios. **According to the EA scenario, it is estimated that the annual GDP growth will amount to an average 2.9%[5] between 2021 and 2050**. The expected growth rate in the same period is 2.5% in the BAU scenario.

Early investments identified by the EA scenario and the gradual and consistent reduction of emissions will result in a **20.7% higher GDP by 2050**, compared to the BAU scenario. The difference between the BAU and the LA scenario is only 11.3% (Figure 5).



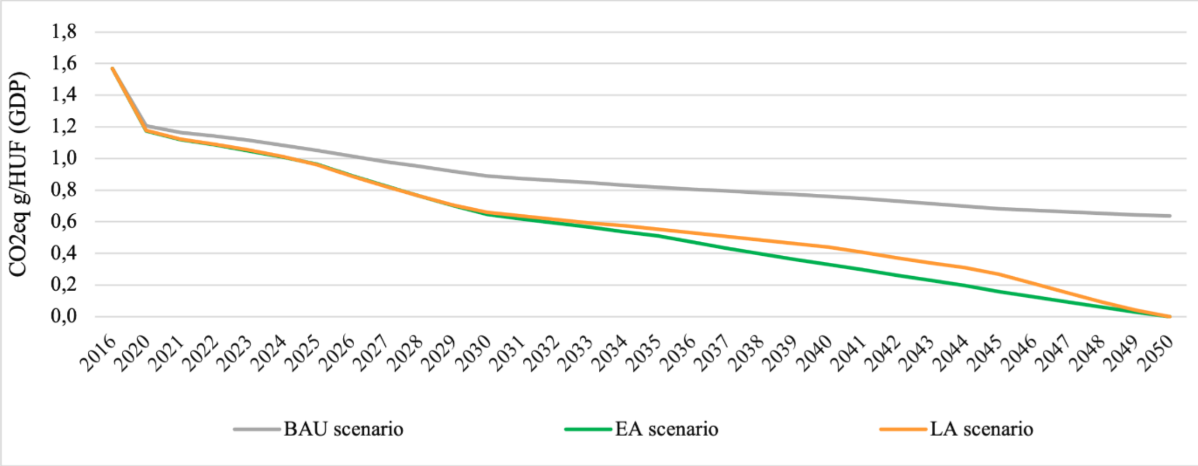
Source: own modeling result

Figure 5 – Real GDP developments by scenario

In addition, according to the EA scenario, **the carbon intensity of the Hungarian economy will gradually decrease** from 1.6 tons of CO_2eq/million HUF in 2016 to zero in 2050, while

[5] Arithmetic average of annual real GDP growth rates projected for the period 2021-2050. A common method for calculating average annual growth rates is the use of the geometric average, which can be used to estimate an increase of 2.6% in the period under review. (See more information at: https://www.unescap.org/sites/default/files/Stats_Brief_Apr2015_Issue_07_Average-growth-rate.pdf)

in the BAU scenario, a carbon intensity of 0.6 tons of CO_2eq/million HUF is expected by 2050 (Figure 6).



Source: Eurostat projection, own modeling result

Figure 6 – Carbon intensity of the Hungarian economy by scenario

According to the analysis, the decarbonization of the national economy creates new jobs in the analyzed sectors. The EA scenario indicates nearly **183,000 new jobs** created by 2050 compared to the BAU scenario, while the LA scenario shows only a third of this number. **Through appropriate education and (re)training programs, the Hungarian economy can benefit from a green transition**.

The analysis of the scenarios up to 2050 reveals that **the BAU scenario does not meet the increased 2030 GHG emissions reduction target nor the 2050 climate neutrality target set in Act no. XLIV of 2020 on Climate Protection**. **However, the cost-benefit analysis shows that the EA scenario brings considerably more economic and employment benefits than does the LA scenario**. At the same time, the EA scenario moderates the uncertainty of the technological transition, which is strongly present in the LA scenario. Furthermore, accelerating the energy transition and the early implementation of investments can incentivize a recovery from the economic crisis caused by the COVID-19 pandemic. **Therefore, in subchapter 4.2, which presents sector-specific results, the focus will be on a comparison between the BAU and EA scenarios**.