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ON-SITE AND NEARBY ELECTRICITY PRODUCTION POTENTIAL IN LATVIA AND CZECHIA

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Abstract. This study provides an overview of current situation and policy planning documents for the implementation of Renewable Energy Sources [RES] in Latvia and Czechia. The main aim is to evaluate the gathered experience in each country in the use of photovoltaics [PV] for electricity production and to define the possible potential of using PV for achieving the EU's energy and climate goals for 2030. Czechia has already long-term experience in instating of on-site PV systems, the growth of which remained stagnant since 2013. On the other hand, Latvia faced a significant PV-installation increase since spring 2022. Special attention is paid to both countries climate analysis, it is a very similar in solar radiation data. Paper provides data of newest support mechanisms, energy policy documents and marketing models which can be applied for a new PV power plant projects in Latvia and Czechia. The article analyzed the data on dynamics of electricity production, consumption and share of PV electricity in both countries for last ten years. The National Energy and Climate Plans [NECPs] for 2021–2030 and the proposed scenarios for achieving the set goals in the field of energy and climate, regarding increasing the use of RES in electricity generation were also studied. Finally, based on all the analyzed data, it can be concluded that both countries have the on-site and nearby electricity production PV potential to achieve their goals in field of RES electricity generation.

Keywords: renewable energy sources, solar energy, electricity, energy transition, photovoltaics.

Introduction

To meet the EU's new energy and climate targets for 2030, Member States must increase the current target to at least 40% of renewable energy sources in the EU's total energy mix. The RepowerEU plan launched this year, includes measures for reduction the EU's dependence on Russian fossil fuels before 2030. As part of expanding the use of RES in electricity generation, industry, transport and buildings, the EC proposes to increase the directive's target to 45% by 2030. (Renewable Energy Targets, n.d.). In this context, each member state had to develop its own National Energy and Climate Plan [NECP] for the period 2021–2030 (National Energy and Climate Plans, n.d.). Latvia and Czechia raised 2030 RES target to 50% and 22%, respectively, in accordance with the recommendations of the European Commission. The Latvian NECP foresees higher than 60% RES contribution in electricity production, up from their present 51.4% in 2021 (Eurostat, n.d.). This target is to be ensured by means of new wind and solar PV installations. Czechia's NECP predicts that RES will account for 17% of gross final consumption of electricity in 2030, mainly due to the significant growth expected for the PV sector (30% approximately) (Bízek, 2022).

In accordance with EU Solar Energy Strategy European Solar Rooftops Initiative (European Commission, 2022) and relative estimates (Bódis et al., 2019), rooftop photovoltaics could provide almost 25% of the EU's electricity consumption, that's more than today's share of natural gas in EU's. The production of electricity from RES in Europe is growing, largely due to the ambitious emission reduction targets set by the European Commission. According to Eurostat database (Eurostat, 2021), gross electricity production from solar photovoltaics in the EU countries increased threefold between 2011 and 2020. A large deal of literature examines the barriers and motivations behind this increase in solar energy (Mirzania et al., 2019; Fina & Fechner, 2021; Weckesser et al., 2021; Galvin, 2022).

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In addition to various support measures and mechanisms from EU Member States, to increase the use of PV rooftop installations, many studies are underway to assess the available roof surfaces or to determine the geographic mapping of the potential of rooftop photovoltaic systems (Georgiou et al., 2022). One of the goals of such studies was the need to highlight the potential of rooftop photovoltaic systems, due they have a high potential to meet EU energy goals. There are studies that estimate the potential of PV rooftop energy communities, for example for Austria it is about 10 GWp (Fina et al., 2020), for Valencia (Spain) PV on the building roofs can produce up to 99% of the electricity consumed by the residential sector (Gómez-Navarro et al., 2021).

RES based energy systems can be a key tool for many governments to create sustainable cities. The basis for a sustainable environment can be created through structures that make optimal use of local RES. According to International Energy Agency [IEA] the building sector accounted for the largest share of global final energy consumption – 36% (International Energy Agency, n.d.). Solar energy used systems have great potential as a renewable energy source to meet the growing energy needs of cities. Currently, the most widely used are rooftop solar PV systems and PV plants located near the city, as most governments finance these types of projects. Unlike other RES, PV allows the use of existing building surfaces (roofs and facades) to generate energy when needed. In addition, they do not make a noise, do not harm the environment while generating energy, require minimal maintenance and already have very reliable systems.

1. Climate analysis

RES generation is affected by the local climatic conditions and therefore optimal design requires thorough investigation of temperature, solar radiation, wind speed and other environmental parameters (Skandalos et al., 2022). In this section, a general description of the climatic conditions in Latvia and the Czech Republic is provided and compared in terms of solar radiation intensity. All necessary climate data were extracted from official homepages of the Czech Hydrometeorological Institute (n.d.) and Latvian Environment, Geology and Meteorology Centre (2020); https://videscentrs.lvgmc.lv/

1.1. General description of Latvian and Czech Republic climate

Latvia's climate is typical European continental, Cfb according to Köppen-Geiger classification (World Maps of Köppen-Geiger Climate Classification, n.d.), influenced with warm, dry summers and rather harsh winters. To a large extent, it is determined by the location of its territory in the temperate climate zone on the coast of the Baltic Sea and the Gulf of Riga. The annual average air temperature in Latvia is +6.8 °C. During the year, the warmest month is July, its average air temperature is +17.8 °C (Figure 1). On the other hand, the coldest month of the year with an average air temperature of −3.1 °C is February. The average annual precipitation in Latvia is 685.6 mm. The rainiest months are August and July with an average of 76.8 and 75.7 mm, while the driest is April with an average of 35.8 mm.

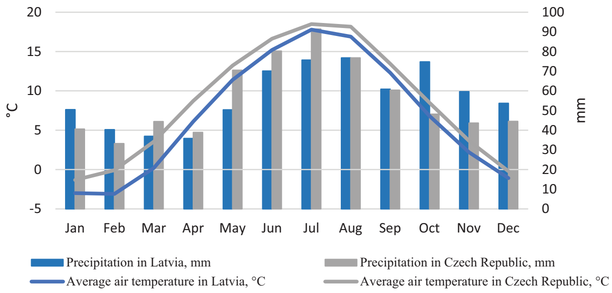


Figure 1. Climatic standard norms of monthly average air temperature and precipitation (Czech Hydrometeorological Institute, n.d.; Latvian Climate, 2020)

Similarly, Köppen-Geiger classification for The Czech climate is Cfb with rather cool and dry summers, and fairly mild and wet winters. To a large extent, it is determined by its location – a landlocked country in Central Europe with the presence of mountainous areas (Dfb in these regions). The annual average air temperature in Czech Republic is +8.4 °C. During the year, the warmest month is July with an average temperature of almost +20 °C, the coldest month of the year is January, when the average temperature falls below 0 °C. The average annual precipitation in Czech Republic is 684 mm. The most precipitation in the Czech Republic falls in June and July, the least in January and February. The Czech Republic has significant variations in annual precipitation due to the highly fragmented relief: from 450 mm/year in the lowlands and 1500 mm/year in mountains areas. A comparison of average air temperature and precipitation between the two climates are presented in Figure 1.

1.2. Solar radiation intensity

In fact, both countries have diverse climate conditions, as the weather can change within a range of a few kilometers. Latvia's climate is greatly influenced by the Baltic Sea, while the Czech Republic's climate is affected by the existence of mountains. Therefore, it is difficult to describe the climate of the country without going into the specifics of the regions. However, there are very similar temperatures in the summer and winter seasons, as well as cloud amounts and solar radiation intensity.

The solar radiation intensity depends on the season, climatic conditions and geographical position. The amount of clouds directly affects how much sunlight reaches the earth's surface, so the spatial distribution of global solar radiation values is related to the distribution of cloud cover. On a European scale, the lowest amount of clouds (10–60%) can be observed on the Mediterranean coast in summer, the highest amount is 60–90% in the north-west of Scandinavia. In Latvia and the Czech Republic, the average cloud cover in summer lies between 55–65% and is significantly less compared to, for example, Germany, Belgium and the Netherlands (Latvian Climate, 2020). Figure 2 illustrates the average daily sunshine hours and average rainfall (mm) in Riga and Prague.

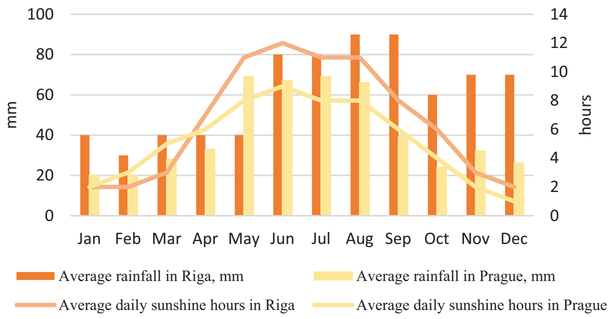


Figure 2. Average daily sunshine hours and average rainfall (mm) in Riga and Prague (Czech Hydrometeorological Institute, n.d.; Latvian Climate, 2020)

In general, the Sun shines an average of 1700–2000 hours a year in Latvia and 1500–1800 hours in Czech Republic. The highest values of shortwave global radiation during the summer in Europe can be observed in the Mediterranean region, where it reaches 250–350 W/m^2, but due to high cloud cover, it does not even exceed 150–200 W/m^2 in some parts of Northwestern Europe (Latvian Climate, 2020). A comparison of the average hourly profiles of direct normal irradiation (DNI) in Riga and Prague is presented in Figure 3. Bearing in mind the dependency on the geographical location, extracted profiles are subjected to similar fluctuations for both countries. Nevertheless, direct solar radiation is higher in Riga during the summer months with peak power of almost 500 W/m^2. Quite the contrary is observed during the wintertime where direct solar intensity in Prague is higher. In addition, the rate of diffuse to direct radiation spectra depends on the location and will also affect the energy yield of photovoltaics (Skandalos et al., 2022).

For our study, PV potential is one of the key statistics in terms of climate data, as it represents the potential level of solar energy utilization. According to Karásek et al. (2023), countries with annual PV performance exceeding 1000 kWh/kWp are suitable for the economic use of PV.

Figure 4 depicts the annual power output (kWh/kWp) of utility scale PV installation, considering monofacial c-Si modules with optimal tilt angle, in Latvia and Czech Republic. A peak value of 1113 kWh/kWp, annually, is observed for the Western part of Latvia with an average of 1040 kWh/kWp for the whole country. PV potential is further increased for the case of Czech Republic, with peak and average values of 1175 kWh/kWp and 1113 kWh/kWp, respectively.

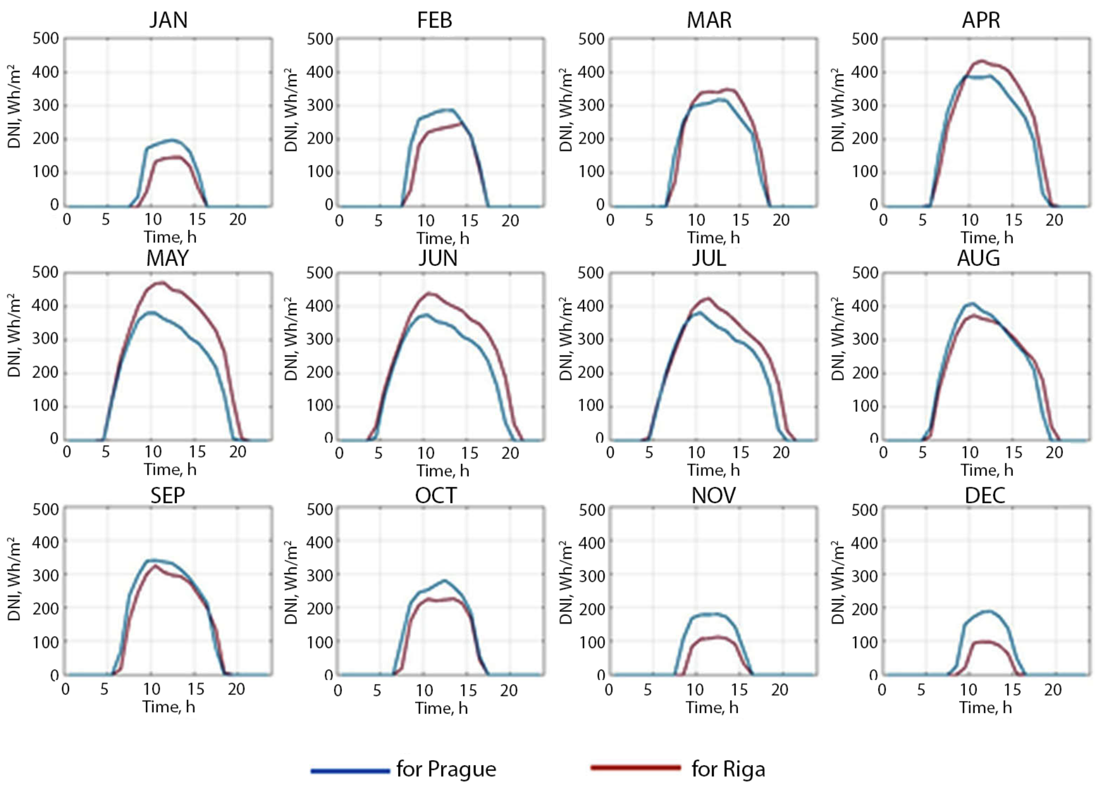
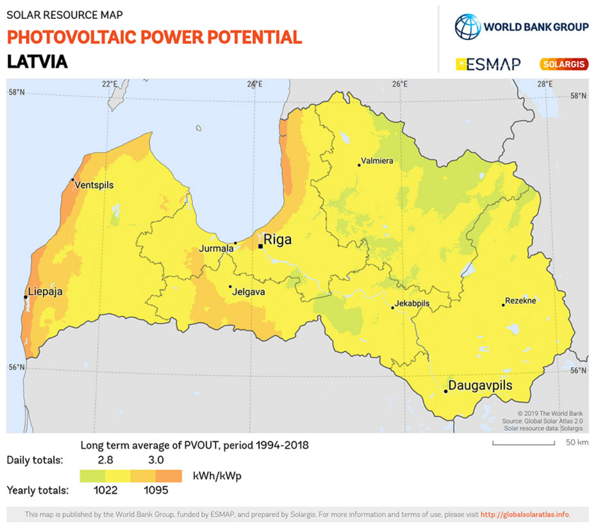


Figure 3. Average hourly profiles of DNI based on Solargis data (Global Solar Atlas, n.d.) for Riga and Prague



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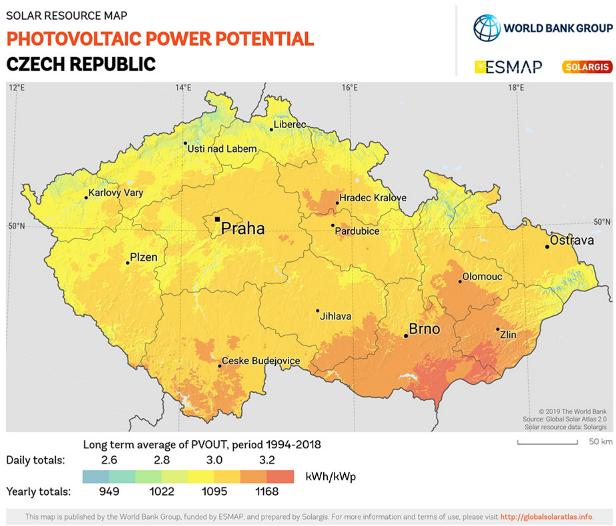


b)

Figure 4. Annual PV potential for Latvia (a) and Czech Republic (b), (Solargis, n.d.)

2. PV electricity policies and support mechanisms

Electricity production from RES was stimulated by feed-in tariff (FIT) schemes in both countries. For Latvia, their validity was ended in the beginning of 2020 switching to the net metering system. Similar in Czech Republic, since the beginning of 2014, only preexisting eligible RES power plants can benefit from FIT support. However, several policies and subsidies have also been implemented in both countries to encourage photovoltaic installations. The main legislative aspects are discussed as follows.

2.1. Policies and support mechanisms in Latvia

In order to achieve the EU targets and increase the energy independence, on July 14, 2022 the Saeima of Latvia adopted the amendments to the Electricity Market Law (Elektroenerģijas tirgus likums, 2005). The amendments are intended to accelerate the faster implementation of RES in electricity generation by promoting the development of solar panels and wind farms. The purpose of the law amendments is to transpose the provisions of two legal acts of the EU Directive No. 2019/944 on common rules concerning the internal market in electricity and amending Directive 2012/27/EU and Directive (EU) 2018/2001 on the use of energy from renewable sources. At the same time, the law envisages the improvement of the existing regulation regarding the electricity market by updating outdated and inappropriate norms. Directive 2019/944 is conceptually aimed at strengthening the role of consumers, and Directive 2018/2001 also covers this area, thus introducing new concepts into national regulation such as the active user, the self-consumer of electricity from RES, co-operating self-consumers of energy from renewable sources, renewable energy purchase agreement, energy community (citizen and renewable energy communities), electricity sharing and electricity sharing agreement. Amendments to the Energy Law (Enerģētikas likums, 1998) were adopted by Saeima on 14.07.2022, Directive No. 2018/2001 of the European Parliament and the Council of 11 December 2018 on the promotion of the use of renewable energy resources is adopted in order to promote energy use from RES and reduce greenhouse gas (GHG) emissions.

From 01.01.2023 major changes took place in the legislation of Latvia, which supports the activities of energy communities, self-consumption of electricity and active users/prosumers, as well as the Ministry of Economics and the Ministry of Environmental Protection and Regional Development (VARAM) are working on the support program and state support regulations for energy communities. According to adopted amendments to the Energy Law, the purpose of energy communities' activity is the production of energy for its members or shareholders, providing economic, social and environmental benefits to its members, shareholders or the territories in which it operates. The primary purpose of the energy communities is not to make a profit. For the community to qualify for state support and participate in the state support program, 80% of the energy produced must be used for self-consumption.

Cost optimal solution to store surplus electricity produced by a RES power plant is to transfer it to the power grid using the advantages of the NET system. Unfortunately, only small households with 11.1 kWp installed PV system could participated in NET system in Latvia. Mover there is a limit for on-site produced electricity accumulation in power grid. The whole produced electricity during the summer should be used back by end of next February. Since 01.01.2023 the NET billing system appeared in Latvia (it was introduced with amendments to the Electricity Market Law) it records the value of the transferred electricity, it is intended for both households and legal entities (the energy community – an association or cooperative), for several objects – remote self-consumption, power limits have been increased up to 50 kW (for the time being until 28.02.2023 in the process of coordination), there is no limit on the accumulation period, the operation of the NET billing system is ensured by the electricity trader.

2.2. Policies and support mechanisms in Czech Republic

The Czech Republic is one of the pioneer countries in Europe that promoted the use of renewable energy with significant policy programs. The national RES support is covered by the Act on Supported Energy Sources (Act no. 165/2012). Energy-producing companies with installed capacities greater than 10 kW are required to have a licence, whereas micro-generation units with self-consumption up to 10 kW are exempt given that electricity in not fed into the grid (Ministerstvo Průmyslu a Obchodu, 2016). The promotion of electricity production was based on regulatory instruments and policies including:

- **Indirect support**: reduction of administrative requirements, mandatory assessment of installation, guarantees of origin of energy and raising consumer awareness.
- **Operating support**: The feed-in energy policy, where operators are obliged to purchase the complete amount of RES electricity, and green bonuses in which the producer needs to seek a purchasing party on his own.
- **Investment support**: Amendment to Act no. 165/2012 and Energy Act, aiming to relaunch the RES development, while introducing energy storage systems in the Czech legislation.
- **Tax exemption**: RES generation is exempt from real estate tax.

Looking forward to 2030, the Ministry of Industry and Trade introduced an auction system aimed at granting support to renewable energy power plants with or without accumulation (CMS, n.d.). In addition to the auction scheme, PV power plants less than 1 MW (6MW in case of wind power) will also be able to receive incentives in the form of an hourly green premium. The positive aspect of the amendment is that for the first time since 2014, the Czech Republic has renewed operational

Table 1. The main support measures and marketing models applied for a new PV power plant projects in Latvia and Czech Republic

	Latvia	Czech Republic
Net system	From 01.01. 2014 net metering system – for generators/prosumers with a small connection (11,1 kW); only for one household From 01.01.2023 net billing system – power limits increased up to 50 kW; generator/prosumer will be able to produce electricity for his needs from RES not only at the facility where it is consumed, but also remotely; share self-generated electricity; for households and legal entities	
Tax credits mechanism		RES power plants (except for geothermal) are exempted from real estate tax
Self-consumption	Installing a microgenerator (electricity production capacity up to 500 kW) in real estate, the permission of the Ministry of Economy is not required. The installer of a microgenerator (for example, solar panels) must apply to the distribution system operator in accordance with the procedure established in the decision No. 1/5 of the Public Services Regulatory Commission of April 14, 2022 "System connection rules for electricity producers".	Power systems up to 10 kWp do not even need to request an electricity production license with an energy regulator, power systems of over 1 MWp require a license from the Ministry of Trade and Industry (Ministerstvo Průmyslu a Obchodu, 2016). The large electricity suppliers (rooftop PVsystems) are strongly represented in the market and provide not only the installation of the systems, but also the financing – the so-called virtual electricity storage systems, which are a form of net metering (Rödl & Partner, n.d.).
Power Purchase Agreement	The general terms and conditions of the sale of green energy govern the sale of electricity produced from renewable energy sources. General apply an "Electricity market law" (Elektroenerģijas tirgus likums, 2005).	Most RES system operators sell subsidized electricity direct marketing of electricity to public grid of self-consumption way themselves and do not use the feed-in tariff, while most of this electricity is purchased by large energy suppliers. Although the Czech Republic has a legal framework for direct electricity trading, including without the use of the public grid (off-grid), so far only a few electricity purchase agreements have been concluded with electricity producers using RES, which also do not receive benefits in the form of a green bonus (Rödl & Partner, n.d.).

support in the field of renewable energy and thus supports new projects (Rödl & Partner, n.d.).

In 2022, subsidies (RES+ call) from the Modernization Fund were lunched to support the implementation of projects leading to reduction of greenhouse gas emissions, the modernization of energy systems, energy efficiency and the increase of RES share in the final energy consumption (Státní fond životního prostředí ČR, n.d.). The subsidy is intended for current of future license holders for business in the energy sector and community RES. Especially for small municipalities the support for rooftop PV systems of public buildings can be up to 75%.

The main support measures and marketing models applied for a new PV power plant projects in Latvia and Czech Republic are summarized in Table 1.

In 2023, Latvian legislation regarding the organization and operation of on-site and nearby electricity production in RES power plant underwent major changes and judging by the prepared detailed regulations (which will be adopted by February 28) for the creation of a complete legal base for energy communities, interest in energy community's organization will be greater. Government of Latvia from 01.01.2023. established a new Ministry of Climate and Energy, which will be responsible for national electricity production and consumption issues.

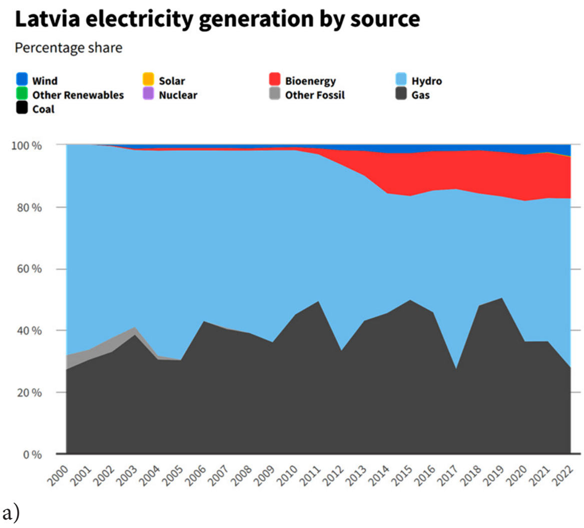
3. Electricity production, consumption and share of PV electricity in Latvia and Czech Republic

Energy balances vary significantly between the two countries with total energy supply of 34.09 TWh and 500.13 TWh for Latvia and Czechia, respectively, in 2021 (International Energy Agency, 2023). According to Eurostat database (Eurostat, n.d.), the annual gross electricity production from renewables in Latvia corresponds to 3.92 TWh indicating a higher RES share compared to Czech Republic. Representative data for a ten-year period are summarized for both countries in Table 2.

In European level, RES share in final energy consumption was 22% in 2021 (Eurostat, 2023). Latvia is third with 42.1% (regarding biomass and hydropower), behind Sweden with 62.6% (biomass, hydropower, wind, heat pumps, biofuel) and Finland with 43.1% (biomass and hydropower). Czechia is eighteenth with 17.67% due to biogas, biofuels, PV and hydro (Figure 5). Photovoltaics are expected to play a role in decarbonization and transition of the energy sector. The installed capacity of 2.2 GW in Czechia corresponds to less than the 3% of the annual share. The situation is even worse in Latvia where annual generation accounts to only 1% of the final energy consumption.

Table 2. Gross electricity production

		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Czechia	*Total* (TWh)	87.34	86.84	86.06	83.81	83.21	86.95	87.91	86.93	81.45	84.95
	RES (TWh)	7.4	8.12	8.83	9.56	9.86	9.68	9.95	10.02	10.22	10.38
Latvia	*Total* (TWh)	6.17	6.21	5.14	5.53	6.43	7.53	6.72	6.44	5.72	5.85
	RES (TWh)	3.28	3.53	3.68	3.81	3.84	3.82	4.06	4.08	4.04	3.92



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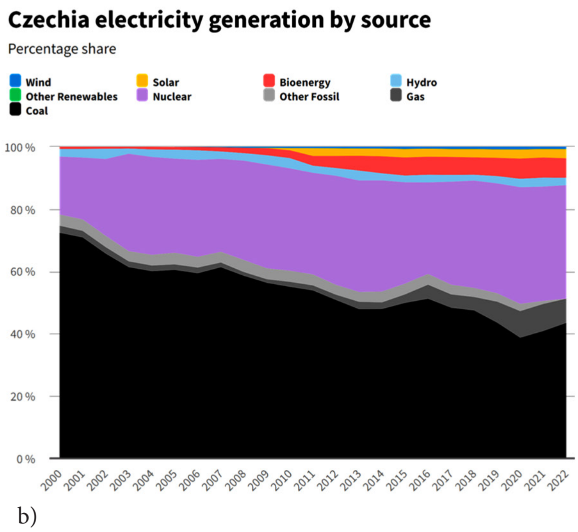

b)

Figure 5. Share (%) of different energy sources in the annual electricity generation of a) Latvia and b) Czech Republic (Ember, n.d.)

However, both countries intend to promote and subsidize photovoltaic installations with the electricity produced from solar PV in Latvia increasing by 40% in 2021. During the last year, around 10,000 self-generating households (microgenerators) were connected to the electricity supply operator, stimulated by the opportunity to participate in the net system and state support for the installation of PV systems. As for the Czech Republic, the majority of the PV projects originated before 2014, where Czech government decided to stop the FiT scheme. The situation then stabilized in the following years, with a more significant increase in installed capacity in recent years, when renewables have again started to gain more attention in the EU. Table 3 summarized data dynamics of PV plants number and installed capacity 2010–2022 (AS Sadales Tīkls, n.d.; Energetický Regulační Úřad, n.d.; Bízek, 2022). Considering microgeneration, almost 50,000 new rooftops (four times more than 2021) were subsidized this year, indicating also the necessity for investments in distribution networks.

Table 3. PV plants number and installed capacity

	Latvia		Czechia	
	Number	MW	Number	MW
2009	N/A	N/A	6032	463
2010	6	0.05	12861	1953
2011	7	0.06	13019	1959
2012	36	0.3	21925	2072
2013	91	0.6	27956	2125
2014	156	1.1	28127	2126
2015	158	2	28276	2123
2016	269	2.8	28351	2127
2017	327	3.5	28348	2130
2018	430	4.6	28412	2119
2019	435	6.6	28554	2128
2020	1105	1	28880	2149
2021	2145	21.1	29140	2157
2022	12000	94	29588	2189

In 2020, households accounted for 26.2% of the final electricity consumption in Latvia and 27% in the Czech Republic. Based on Eurostat data, electricity used for lighting and most electrical devices makes up 14.5%, for water heating about 15.1%, cooking devices 6.1%, space cooling and other end-uses cover 0.4% and 1.0% of the energy used by households.

Table 4 shows countries energy for final consumption data and electricity use by type of use. In recent years, an increase in household electricity consumption was observed, mainly due to the restrictions imposed by Covid-19.

Conclusions

Latvia and Czech Republic have both set impressive goals for the use of renewables, in accordance with the EU new energy and climate targets, till 2030. Major changes in the legislation related to the PV electricity has been occurred, which are expected to increase of PV electricity share in the total energy mix of both countries.

It is still premature to determine whether these goals can be achieved. However, the climate analysis performed in this paper indicated that both countries have the required potential. Based on Solargis data, estimated part of the country's territory on which PV installations producing the equivalent of annual electricity consumption can be placed, the so-called PV-equivalent area, for Czechia is 1.37% and for Latvia is 0.3% and maximum practical PV potential respectively 1113 kWh/kWp/year and 1175 kWh/kWp/year. With such potentials, a significant but realistic increase in RES electricity is needed. Now, the Czech Republic is not a leader in terms of energy production from RES, but the Czech energy system can include much higher renewable capacities than the current ambitions, for example, to achieve the declared 10 GW solar power capacity, 7.9 GW must be added by 2030 without reducing production.

Latvia is currently one of the leaders in the EU in the use of renewable energy sources, but in 2021 photovoltaic power generated only 6.8 GWh, which is only 0.1% of the country's gross electricity production. According to the NECP, additional capacities of solar energy (connected to the grid) must be introduced, in order to reach the set targets, it must be increased to about 20 MW, but like the Czech Republic, Latvia also has a greater PV potential. For example, based on COME RES project results, the potential of solar rooftops for energy communities was estimated at 844 MW, of which 644 MW for multi-apartment buildings. Installing new electricity generating capacities, especially those that depend on solar energy,

Table 4. Electricity use by type in 2020

	Available for final consumption, GWh	Households, GWh	Electrical appliances, GWh	Water heating, GWh	Cooking devices, GWh	Cooling, GWh	Other, GWh
Czechia	303 745.0	82 011.1	11 891.6	12 383.7	5002.7	328.0	820.1
Latvia	45 061.6	12 166.6	1764.2	1837.2	742.2	48.7	121.7

should be aware that electricity needs to be produced at the same time in an amount that corresponds to the amount of consumption at a given moment. Therefore, a clear national strategy and coordinated actions for the creation of a balanced portfolio of electricity production capacities would be especially useful at the moment.

Acknowledgements

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