DOI: 10.28934/ea.24.57.2.pp17-35

PRELIMINARY REPORT

'Green' Energy in 'Red' Yugoslavia: The Failure of Hydroelectric Power in Yugoslavia between the 1960s and 1980s

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ABSTRACT
This research focuses on the positive and negative experiences with renewable energy in socialist Yugoslavia in order to provide suggestions to contemporary policymakers based on a historical experience that is very limited. The fact that the country at times produced up to 75% of its electricity for industry and households in hydroelectric power plants is an admirable achievement from the perspective of the contemporary EU Green Deal. However, the experiences were sometimes catastrophic, ranging from city blackouts to prolonged production stoppages in industry. Despite some exceptions, the existing Serbian or regional scholarship has not yet analyzed this topic except from technological or engineering perspectives. Starting from that point, this research employs a critique of the sources as a standard historical method. It is based on primary and secondary sources, stretching from official Yugoslav policies and statistics, expert analyses, and newspaper articles. Previous experiences with electricity production in hydroelectric power plants in Yugoslavia are crucial in adequately approaching the EU Green Deal agenda that includes the expansion of renewable energy sources, which is and will most certainly be one of the pressing challenges in the future. At the current level of technological capabilities, the transition to renewable energy, whether from hydro, solar, wind, or geothermal sources, faces a challenge in providing a continuous flow of energy to industry and households. Lacking capacities for storage of vast amounts of electric energy, the solutions to this challenge will have to be found in conventional sources, among which nuclear power currently seems to be the best option, despite other environmental and safety concerns it raises.

Keywords: *Yugoslavia, hydroelectric power, renewable energy*

JEL Classification: N74, Q42, Q48

INTRODUCTION

Conventional generators of electric energy supplied from coal, oil, gas, or nuclear fuel are still considered invaluable in any electrical power system due to the main characteristics they share, primarily their predictability and ability to continuously provide electricity. Equally important is their capability to change their output depending on the changes in demand, which is crucial for the stability of electrical power systems (Freris and Infield, 2008: 52-3).

On the other hand, one characteristic shared by all renewable sources is their variability and unpredictability, at least until an operational and economic solution for the storage of electric power is found. In the case of solar power, it is understandable that the intensity of solar radiation varies by region and season, which suggests some level of predictability. The problem lies in unpredictable weather patterns. For example, cloud formations can significantly reduce solar radiation and cause rapid variations in intensity that can compromise the power system's stability. This problem is even greater with wind power. Besides the difficulty of predicting wind patterns in any reasonable time scale (except regarding general trends), the technology is designed to generate electricity at a rated wind speed that varies from manufacturer to manufacturer. In the case of lower wind speeds, the electricity generation drops exponentially, while at higher winds it does not go further than rated output. At very high speeds, the turbine must be shut down to avoid potentially catastrophic damage (Freris and Infield, 2008: 31-37).

Large hydroelectric power plants (HEPP) with accumulation reservoirs are the most important to analyze in this research because of their technical capabilities and the fact that they were dominant in Yugoslavia. They can store water to be used when required for electricity production; continuously, if the reservoir is big enough, or when the electricity demand requires it most. Such a configuration theoretically means flexible electricity generation, since it allows for a rapid response to predicted and unexpected consumer demand changes. Their greatest downside is the substantial capital investment necessary for construction, the problem that is offset by the low cost of electricity generation, once constructed and connected to the electric power grid (Freris and Infield, 2008: 24-25). The case of Norway shows that almost the entire electric power generating system can be based on hydropower (close to 96% in 2023), although it is a fact that the extremely favorable hydrological and geographical conditions are unique to this country and should be considered as an exception rather than a rule.[1]

More importantly, electric power systems must balance production with demand in order to maintain system stability, considering that the available technology does not allow for electric energy to be stored economically. This problem necessitates considerable 'demand forecasting' to prepare available production facilities adequately for the expected demand. Even though decades of experience with electricity generation at a global level led to the development of sophisticated and accurate mathematical techniques that are continuously refined, 'all methods are essentially based on the fact that demand exhibits regular patterns' (such as national habits, weather patterns and prognosis, etc.), which occasionally cannot be predicted with the necessary accuracy (Freris and Infield, 2008: 64-66).

The previous discussion shows that renewable energy sources are highly dependent on weather conditions, which makes them unpredictable, and a potential liability for system stability. At the current relatively modest level of incorporation or renewables in integrated electric power systems, this does not present too big of a problem in 'demand forecasting,' simply because the level of unpredictability they bring into the equation does not add significantly to uncertainties in balancing between supply and demand. However, it is also a fact that the margin of error in 'demand forecasting' will rise in direct relation to greater incorporation of renewables into electric generation systems, regardless of how gradual it may be in different countries or on a global level.

While it is technically feasible for a country to rely heavily on a mix of renewable energy sources, this requires overcoming significant technical, economic, and regulatory challenges. Balancing intermittency, ensuring grid stability, investing in storage solutions, upgrading infrastructure, and creating supportive policies are all critical components of a successful transition to high levels of renewable energy reliance. Furthermore, renewable energy technologies are relatively new compared to traditional power-generating sources. This presents an additional challenge because there is less historical data available to build reliable forecasting models. Considering the current rapid technological evolution, it can be anticipated that this problem will rapidly grow in the future, which will only further complicate forecasting.

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[1] "How Norway produces hydropower with a minimal carbon footprint," *Business Norway*, February 7, 2024, https://businessnorway.com/articles/how-norway-produces-hydropower-with-a-minimal-carbon-footprint, accessed on June 5, 2024.

This article aims to investigate potential economic, social, and political problems that may occur as a consequence of high dependency on renewable sources in electricity generation, based on the Yugoslav historical experience. Due to specific historical development in the period after the Second World War and the availability of a substantial and previously virtually untapped hydrological potential, electricity generation in Yugoslavia between the 1960s and 1980s was predominantly based on a system of large HEPPs as a renewable energy source or 'green' energy. Even though renewable energy as a concept only started to emerge in the observed period and predominantly in the most developed countries, the Yugoslav experience with hydroelectric power is relevant for offering otherwise very limited historical lessons for contemporary policymakers in the field. In the observed period, the annual electricity production in Yugoslav HEPPs seldom fell below the symbolic 50% margin, with seasonal peaks of up to 75% (*Table 1*). The remaining electricity was produced in thermal power plants based on fossil fuels (lignite and heavy oil).

Considering the contemporary push for higher use of renewable sources in electricity generation in developed countries, such a favorable energy mix would catapult Yugoslavia among the currently leading EU countries in the field of use of renewable sources.[2] However, the overwhelming reliance on hydropower for electricity generation in Yugoslavia also produced many political, economic, and social problems that forced the Yugoslav political establishment to redefine the country's energy strategy. These problems were further exacerbated by the Oil Crisis of the 1970s, which caused prolonged economic problems on a global level. The choice eventually fell on the use of fossil fuels as a primary source for electricity production and power generation in the late 1970s and 1980s, with a particular focus on thermal power plants (TPP) and the use of the low-grade lignite that was abundantly available in the country, and that could secure predictable power generation.

This research employs standard historical methods based on the content analysis of primary and secondary sources, stretching from official Yugoslav policies and statistics, expert analyses, and newspaper articles. The existing Serbian or regional scholarship has not yet properly analyzed this topic except from technological or engineering perspectives. The research of Saša Ilić presents a notable exception, although even his contribution does not change the fact that this field of research has yet to spark proper interest within the wider academic community (Ilić, 2020; 2000; 1996).[3] Focusing on the experiences in Bosnia and Herzegovina, Sarač-Rujanac's research provides the most recent and inspiring contributions to the scholarship (Sarač-Rujanac, 2024; 2022). Starting from that point, this research aims to provide an overarching analysis from a historical perspective of the gradual evolution and ultimate failure of the Yugoslav energy policies based on hydroelectric power, focusing on continuous problems in the supply of electricity and solutions found to navigate them. Even though these challenges caused myriads of political, economic and societal problems, this article does not deal with the political aspects directly as it would require an extended analysis that cannot be performed within the limits of this paper. The majority of sources analyzed in this article come from the Open Society Archives in Budapest which provides an excellent combination of the Yugoslav press-clipping and extensive analyses performed by the Radio Free Europe/Radio Liberty experts.

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[2] *Eurostat*, "Renewable energy statistics," December 2023, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Renewable_energy_statistics#Wind_and_water_provide_most_renewable_electricity.3B_solar_is_the_fastest-growing_energy_source, accessed on June 3, 2024. In 2022, only Sweden, Denmark, and Austria produced more than 70% of electricity from renewable sources in the EU, with Norway leading the list with up to 120%. Data for Serbia show that more than 38% of electricity was produced from renewable sources, although the Statistical Office of the Republic of Serbia shows lower percentage which was taken as more accurate and used in this article.

[3] Ilić's pioneering work in this field covers several articles and chapters in edited volumes, as well as other important contributions in the field of economic history of Serbia and Yugoslavia.

The Yugoslav experience with hydroelectric power provides a rare historical example of a country struggling to achieve a continuous energy balance based on this renewable energy source. While it could be technologically possible to achieve stable and overwhelming dependency on renewable sources in electricity generation, the contemporary level of technological development may not be sufficient for governments to respond to challenges coming from the general unpredictability of these sources, mostly related to their dependence on varying weather patterns. Considering the existing EU Green Deal agenda, conclusions presented in this article may prove to be useful to policymakers in Serbia, the region, the EU, and globally in dealing with the issue of battling climate change and promoting a rapid shift toward green energy. Although nuclear energy could prove to be the only available answer to these challenges, this option is not without problems and has to be addressed with considerable attention.

THE BACKGROUND

In 2022, the Serbian national electricity provider, *Elektroprivreda Srbije* (EPS), generated roughly 28.7 % of electricity from renewable sources, predominantly through hydroelectric power plants (HEPPs).[4] The share of renewable sources in the Serbian electric energy balance was lower than the European Union (EU) average, which rose sharply in recent years to reach 41.2% in 2022, but it was still comparable to some much more developed EU member states (e.g. France – 27.3%, or the Czech Republic - 15.5%).[5] This information can be read as a result of the continuous dedication of successive governments of the Republic of Serbia to the use of renewable energy. It also puts Serbia in a good negotiation position regarding the country's future EU membership in this sector, considering that the EU's Green Deal policies (2020) are designed to reduce net greenhouse gas emissions by at least 55 % by 2030, compared to 1990 levels. An additional benefit is that Serbian politicians are more than happy to exploit such an opportunity for personal promotion, both in the country and before international partners, despite warnings from the experts that the adequate energy mix is country-specific and difficult to reach in the timeline presented in often ambitious strategic documents.[6]

However, the existing energy balance in Serbia represents an echo of Yugoslav policies and energy strategies developed over the period between the 1950s and the late 1980s. Particularly in the earlier period, electrification was considered a component of the much broader project of the country's industrialization and modernization of the economy and society in general.[7] The data in *Table 1* also show that the energy balance and the use of hydropower for electricity generation in Serbia have not changed significantly since the late 1980s. The disintegration of Yugoslavia, wars for the Yugoslav succession during the 1990s, combined with a deep economic crisis in Serbia as a consequence of UN sanctions and NATO bombing of 1999, resulted in a huge gap in investments in the energy sector, but also in a lack of need for new capacities. One of the outcomes of these serious challenges was the rapid deindustrialization of the country during the 1990s and early 2000s, which only further decreased the need for electric power in industry as the greatest consumer (Šojić, 2014: 61).[8]

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[4] *Energy Balances, 2022* (Belgrade: Statistical Office of the Republic of Serbia, 2024), 20. Hydroelectric power plants produced roughly 26 % of electricity, with the largest one, *Đerdap 1* providing up to 20 % of the for the EPS alone. *Elektroprivreda Srbije*, "Hydro power plants," https://www.eps.rs/eng/Poslovanje-EE/Pages/Hidroelektrane.aspx, accessed on June 3, 2024.

[5] *Eurostat*, "Renewable energy statistics," December 2023, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Renewable_energy_statistics#Wind_and_water_provide_most_renewable_electricity.3B_solar_is_the_fastest-growing_energy_source, accessed on June 3, 2024.

[6] Milica Radenković Jeremić, "Obnovljiva energija u Srbiji: Mnogo planirano, nešto započeto, cilj daleko," *BBC News na srpskom*, October 31, 2024.

[7] Dženita Sarač-Rujanac, "Svjetlo u tunelu: Električna energija i elektrifikacija u Bosni i Hercegovini do sredine 1970-ih godina," *Prilozi*, 51/2022, 257.

[8] The volume of industrial production in Serbia in 2012 was only 38.4 % of the production in 1989.

More importantly, data shows that Yugoslavia produced roughly 70% of its electricity from hydropower in the early 1960s, a worthy achievement regarding the contemporary push for reducing CO_2 emissions. Although the percentage gradually fell in the following years and decades it is important to emphasize that until 1974, more than half of electricity was produced by HEPPs (52.4%).[9] In addition, these data represent only gross annual production. During different seasons, and depending on weather patterns or hydrological conditions, the Yugoslav HEPPs experienced periods of much higher shares of electricity production.[10]

Table 1. Production of electricity in Yugoslavia and Serbia, 1960-1989 (GW/h)

	1960	**1965**	**1970**	**1975**	**1980**	**1985**	**1989**
Yugoslavia	8.928	15.523	26.023	40.040	59.435	74.802	82.775
Serbia	-	4.705*	8.694	17.532	27.225	35.722	40.102
Serbia (%)	-	30.3*	33.4	43.8	45.8	47.7	48.4
HEPP electricity production in Yugoslavia (%)	67%	57.9	56.6	48.2	47.4	32.4	28.4
HEPP electricity production in Serbia (%)	-	24.8*	38.4	48.9	40.3	27.2	26.4

Source: Statistical Office of the Republic of Serbia[11]

On the other hand, it would be misleading to argue that environmental concerns presented a significant or major component of the Yugoslav energy strategy planning, despite the fact that environmental awareness started to emerge within political structures during the 1970s.[12] During the period analyzed in this article, few countries (if any), including the EU, incorporated ecological and climate concerns in their energy policies and strategies, and the same can be said about the concept of renewable energy (Hey, 2005: 17-28).[13] Yugoslavia's relatively high dependency on hydroelectric power was a consequence of combined geographical and hydrological potentials and a specific process of industrialization after the Second World War.

The Yugoslav immense hydrological potential with three major river flows (Danube, Sava, and Drina) was an untapped resource before the Second World War. Initial estimates showed that the hydropotential of Yugoslavia accounted for roughly 1.6% of the entire planet. Only Norway had

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[9] *Statistički godišnjak Jugoslavije, 1981* (Beograd: Savezni zavod za statistiku, 1981), 265.

[10] Blinken OSA Archivum 300-10-2 box 76 Coal 1963-1983 (in further reference HU OSA 300-10-2 box 76 Coal 1963-1983). "Spasonosna jesen uglja," *Privredni pregled*, July 31, 1978. For example, during the summer of 1978, Yugoslav HEPPs produced up to 75 % of the electricity due to favorable hydrologic conditions.

[11] Data was collected from *Statistički godišnjak Jugoslavije* [Statistical Yearbook of Yugoslavia] for 1981 and 1991, and *Statistički godišnjak Socijalističke Republike Srbije* [Statistical Yearbook of the Socialist Republic of Serbia] for 1975, 1976, 1981, 1986, and 1991. Data for Serbia are available only from 1966, and these were included in the Table 1, with a huge gap between 1953 and 1974. These publications are available on the website of the *Statistical Office of the Republic of Serbia*, "Library," https://www.stat.gov.rs/en-US/korisnicka-podrska/biblioteka, accessed on June 4, 2024.

[12] For example, in 1972, the Environmental Commission of the Assembly of the Socialist Republic of Slovenia was established. Three years later, the Republic Committee for Environmental Protection was established within the Executive Council of the Assembly of the Socialist Republic of Slovenia. Katarina Polajnar Horvat, Aleš Smrekar, Matija Zorn, "The Development of Environmental Thought in Slovenia: A Short Overview," *Ekonomska i ekohistorija*, Vol. X, 10/2014, 19; Stane Peterlin, Miroslav Kališnik (eds.), *Zelena knjiga o ogroženosti okolja v Sloveniji = The Green book on the threat to the environment in Slovenia* (Ljubljana: Prirodoslovno društvo Slovenije, Zavod za spomeniško varstvo SR Slovenije, 1972).

[13] Even though the environmental impact of industrial pollution started to be seriously debated in the early 1970s, it is important to emphasize that the EU environmental policy strategy only gradually evolved since then, mostly through a number of strategic policy documents, such as Environmental Action Programmes, although they were usually not legally binding. The EU's Green Deal was delivered only in 2020.

greater absolute hydro sources, while Switzerland, Sweden, and Finland had a better per capita ratio (Ilić, 2020: 112). After 1945, the global process of socialist modernization was deeply related to the process of industrialization, which 'represented not only a method but also a strategic aim of the complex socio-economic transformation.' The Yugoslav experience did not differ significantly. Electrification was a necessary precondition for an ambitious modernization project of a severely underdeveloped country and the Yugoslav First Five-Year Plan (1947-1951)[14] included the construction of large-scale production facilities, of which the *Bajina Bašta* HEPP on the river Drina was the first among many to be built (Vučetić, 2018: 47-49). The *Đerdap 1* HEPP (1970) was the crowning jewel in this process. It was a joint Yugoslav-Romanian project put in operation between 1970 and 1972, and it still holds the title of the second-largest HEPP in Europe by installed capacity (Ilić, 2020: 112-113).[15]

ECONOMIC CHALLENGES

The greatest problem regarding electricity generation in Yugoslavia during the 1960s was the lack of production facilities. Even though the construction of hydro and thermal power plants grew so rapidly since 1945 that it could be measured in hundreds, it was simply not enough to follow the pace of rapid industrialization.[16] However, the official records suggest that this was not the case. The consumption of electricity by industry between 1950/51 and 1985 grew by a factor of 23.9, while electricity generation in the same period grew by a factor of 31 (*Table 2*). At the same time, the consumption of electricity by households grew by a factor of 68.9, which indirectly reveals the main cause of the instability of the Yugoslav electric power system, suggesting several significant insights.

Firstly, despite the astonishing pace of industrialization of Yugoslavia and the modernization of its economy in general (*Table 2*), the country achieved even better results in the modernization of the society, at the very least considering the access to electricity (heating, household appliances, street lighting, etc.), but in other aspects as well (Miljković, 2023; Vučetić, 2012, Selinić, 2005). Secondly, such a rapid and continuous rise in the consumption of electricity by households would make any potential disturbances in supply politically dangerous, especially in a socialist system that promised social equality and well-being for everybody, thus confirming its superiority over capitalist and other competing ideologies (Kornai, 1992: 49-54). This is particularly important as it can be argued that the stability of the entire state system was at least partially dependent on the state's capacity to deliver electricity to the population, among other benefits of modern and affluent societies. In fact, the rapid expansion of the use of electricity by households was expected to continue in the following decades, partly due to the low starting point in the 1940s (*Table 2*), but also because despite all the successes in that process, during the 1960s the use of electricity

[14] The First Five-Year Plan failed to meet ambitious goals due to a combination of foreign political and internal challenges – the Tito-Stalin split of 1948 caused the economic blockade by the Soviet Union and its satellites, and increased military spending, while severe droughts of 1950 and 1952 presented an additional economic and social challenge. Therefore, the implementation of the plan was extended to 1952, although the strategy for industrialization presented in the First Five-Year Plan continued to be implemented until 1956, without a formal plan. Branko Petranović, *Istorija Jugoslavije: 1918-1988. Knj. 3, Socijalistička Jugoslavija: 1945-1988* (Beograd: Nolit, 1988).

[15] *Energynews*, "Europe's Largest Dams in 2024," May 1, 2024, https://energynews.pro/en/europes-largest-dams-in-2024/, accessed on June 5, 2024; The American Society of Mechanical Engineers, "Largest Hydroelectric Dam on Each Continent," February 1, 2022, https://www.asme.org/topics-resources/content/largest-hydroelectric-dam-on-each-continent, accessed on June 5, 2024. The largest in Europe is Volga HEPP in Russia, with installed capacity of 2,700 MW, while Đerdap 1 capacity is 2,160 MW and it is shared between Serbia and Romania.

[16] By 1958, Yugoslavia constructed 366 small and big hydroelectric power plants, 16 thermal power plants, and more than 10,000 km of electric grid.

per capita was still three times lower than in developed European countries.[17] Finally, while the supply of electricity for the industry was equally important for the country's economic and political stability, potential power cuts in the industry may not be immediately visible to a larger population, while the solution to problems resulting from production stoppages and related financial losses, could be postponed for a later period.

Table 2. Production and consumption of electricity by industry and households in Yugoslavia

	1946	1950	1955	1960	1965	1970	1975	1980	1985
Industrial production in Yugoslavia (index 1955=100)	33	72	100	187	310	417	614	848	970
Electricity generation in Yugoslavia (GWh)	1.150	2.408	4.340	8.928	15.523	26.023	40.040	59.435	74.804
Consumption of electricity by industry (GWh)	-	1.598*	2.624	5.245	9.267	13.814	21.466	28.679	38.287
Consumption of electricity by households (GWh)	-	259*	514	1.217	2.876	6.082	10.351	15.566	17.831

Source: Yugoslavia 1918-1988. Statistical Yearbook[18]

The available data in *Table 2* present annual production and consumption levels of electricity, and it can be expected that seasonal changes in any category would only further complicate existing problems. These issues would be further emphasized by the fact that during the 1960s, Yugoslavia produced, on average, more than 50% of electricity in HEPPs (*Table 1*), making it heavily dependent on favorable weather conditions and seasonal patterns.

One of the first major electro-energy crises in Yugoslavia happened as early as the winter of 1959/60, revealing many deficiencies in electricity production. According to the report of the Federal Assembly, the planning was somewhat ambitious and based on annual gross production levels, not taking into account seasonal fluctuations. It was also concluded that the main impact of the crisis was felt and absorbed by industry, which consequently had an impact on the entire country's economy and underperformance regarding designated targets in the plan. The impact of reduced electricity generation was particularly felt by the most advanced industrial sectors that were the largest consumers of electricity, such as the production of aluminum, carbide, ferroalloys, and foundries.[19]

The situation was particularly difficult in facilities for the electrolysis of aluminum where the country's biggest aluminum producer in Kidričevo (Slovenia) emphasized that they 'consider electric power as a raw material,' insisting that this branch of industry should be excepted from 'any administrative distribution of electricity.'[20] Due to restrictions and intermittent supply of electricity, the production at Kidričevo stopped in November 1959 and did not recover until February 1960. Although electricity was generally available even for export during that winter,

[17] Sarač-Rujanac, "Svjetlo u tunelu," 266.

[18] *Yugoslavia 1918-1988. Statistical Yearbook* (Belgrade: Federal Statistical Office of the Socialist Federal Republic of Yugoslavia, 1989), 247-252. The data for consumption of electricity in industry and households for 1950 are not available, so the data used in this column is for 1951.

[19] HU OSA 300-10-2, Records of Radio Free Europe/Radio Liberty Research Institute, Balkan Section: Albanian and Yugoslav Files, box 140 (in further reference HU OSA 300-10-2-140). "Joint session of the Committee for Industry of the Federal Chamber and a group of deputies of the Economic Chamber," *Borba*, February 21, 1964, 4.

[20] HU OSA 300-10-2-140. V. Filipović, "Joint session of the Committee for Industry of the Federal Chamber and a group of deputies of the Economic Chamber," *Borba*, February 21, 1964, 4.

the problem was that such a big industrial facility could not restart production with a flick of a switch, which forced them to wait for the supply to fully stabilize. The power cuts also caused damage to installations and breakdowns of industrial machines and equipment that necessitated huge amounts of unexpected and unnecessary investments. Finally, with a significant reduction in aluminum production, Yugoslavia had to import this commodity to a much higher volume than planned or necessary.[21]

One of the major causes of these power cuts in the winter of 1959/60 was the heavy reliance on HEPPs, which depend on favorable hydrologic cycles to fill their reservoirs and use them for production during the season when the rainfall is lower. Even though Yugoslavia could have theoretically enjoyed complementing cycles, having Dinaric rivers that receive a lot of water during the winter and Alpine rivers that receive most of the water during spring and summer, such a favorable combination never worked properly, mostly because the poor timing in construction of new HEPPs in adequate regions and inadequate distribution grid. By 1965 it was calculated that total delays in construction of electric power plants exceeded 150 months. The main reasons were related to inadequate coordination with the facility and electric grid construction, along with delays in equipment delivery by both domestic and foreign suppliers, which postponed the finalization of different projects by more than a year. Other factors specific to socialist economies, such as overly ambitious planning and a lack of foreign currency also contributed to these delays. Eventually, in the following years, the problems of electricity production and supply during the winter started to be felt even during summer with the first restrictions already introduced in August and even harsher during the September-November period.[22]

By early 1964 the situation had not changed significantly and the journalist of *Delo* complained that '[w]e shall be able to avoid that summer crisis only if exceptionally heavy rainfall should occur in the south-east of the country during summertime, which as a rule does not happen there.'[23] Anticipating these problems, the Official Journal of the SFRY (*Službeni list SFRJ*) published a contingency plan as early as February 1964 (the General Order of Priority for Electricity Supply) from the Federal Secretariat for Industry, outlining restrictions on electricity supply. Unsurprisingly, the plan reveals that the main concern for the policy-makers was to provide a continuous supply for the households, sacrificing the industry.[24]

The first group for restriction were 'electric furnaces for the production of iron,' ferrous and other metal alloys, and carbides that would suffer 70-100% of the electricity supply restrictions in case of any instability in production. Alongside these facilities, electricity would be reduced for the heating of 'business premises and the lighting of shop windows and [neon] advertisements' to the same measure. If these restrictions were insufficient, the next in line would be facilities 'for the production of aluminum by electrolysis' to the same measure as with iron smelting furnaces and in favor of 'heating of housing and street lighting.'[25]

While this prioritization of households over industry regarding electricity restrictions fits neatly with the strategy expected to be employed in Yugoslavia, it is easy to see that during the 1960s this was more a general annual pattern than an odd event based on unexpected weather. Furthermore, it seems that the necessary and accurate weather predictions also failed almost

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21 HU OSA 300-10-2-140. Electric power 1963-1964; Electricity: Electric Power, 1974-1975. "Why the present and the forthcoming crisis?," *Delo*, February 21, 1964, 3.
22 HU OSA 300-10-2-140. Electric power 1963-1964; Electricity: Electric Power, 1974-1975. "Why the present and the forthcoming crisis?," *Delo*, February 21, 1964, 3; HU OSA 300-10-2-76. "Cost cuts 47,000 million," *Večernji list*, November 12, 1965, 5; "Reasons for lag in electric power plant construction," *Privredni pregled*, July 19, 1966, 4.
23 HU OSA 300-10-2-140. Electric power 1963-1964; Electricity: Electric Power, 1974-1975. "Why the present and the forthcoming crisis?," *Delo*, February 21, 1964, 3.
24 HU OSA 300-10-2-140. *Službeni list SFRJ*, No. 7, February 12, 1964, 189-190.
25 *Ibid*.

continuously, although even if they were accurate, it would have been difficult to make any appropriate accommodations for the electric power system dependent on hydropower to such a degree. The fall and winter of 1963 were 'exceptionally dry' and the HEPPs reservoirs were empty by February 1964, causing them to employ only 50% of their installed capacity by that time. The official estimates also revealed that similar shortages will continue in the following couple of years until new facilities for electricity generation are connected to the grid.[26] The Council for Industry of the Federal National Assembly also estimated that '[t]he prospects for normal electric power supply in the years leading up to 1970 were very poor, even worse than at the beginning of 1964.'[27] Even though it is very difficult to calculate all the costs of electricity reduction, one official estimate suggested that the total loss only in 1965 added up to roughly 47 billion dinars or ' one-third of the total social product of the Yugoslav chemical industry,' taking into account only the price of electricity that was not delivered to the industry.[28] It is easy to argue that the actual losses were much higher if all the losses in production, delays in deliveries to customers in the country and abroad, and rise in prices of final products were to be included. Unsurprisingly, another estimate published only ten days later calculated all the losses to 120 billion dinars.[29]

To alleviate the consequences of electricity reductions, all available thermal power plants that used coal were put online and on the maximum production level. This included even small thermal power plants in various enterprises 'which had not been operating for some time.'[30] Some companies also made plans to invest in the construction of their own electricity-generating capacities. This was true for the *Jugohrom* company (Northern Macedonia), which decided in 1965 to build an HEPP in order to secure a steady supply and lower price of electricity, which was necessary for the production of chrome products and ferroalloys, usually at the top of the list for electricity reductions.[31] This project was not realized eventually, mostly because the banks were reluctant to finance it due to the company's failing production, and the problems for *Jugohrom* continued. A similar obstacle appeared with a project for high-voltage power lines that would connect the company with other republics that had electricity to spare. By as early as 1967, the company was utilizing only 40% of its capacities due to intermittent supply and high prices of electricity. Considering that *Jugohrom* consumed 30-40% of electricity in Macedonia, it is easy to imagine how devastating were the power cuts for the economy of the entire republic (Ristoski, 2009: 651).[32]

While a decision to adequately balance the energy mix in the country's electric power system seems rational, such a policy created a myriad of additional problems. Firstly, coal mines were not capable of rapidly raising their production to meet the growing demand, nor it was possible to adequately plan for such contingencies. It was also often impossible and uneconomical to store large quantities of coal to meet an unexpected demand in the future. Secondly, thermal power plants consumed most of the coal produced in the country and continuous fluctuation in their demand made coal mines' production uneconomical. This created a labor problem, as the miners' salaries were low since mines could not operate a full capacity throughout the year without the possibility of selling coal to customers. On top of that, working conditions were bad. These were the main reasons why the turnover in mine personnel was very high and the shortage of labor a

[26] HU OSA 300-10-2-140. "Water and electricity crisis after a dry autumn and winter,' *Borba*, February 15, 1964, 5.

[27] HU OSA 300-10-2-76. R. Jovanovski, "Future production of electric power," *Privredni pregled*, September 25, 1965, 7.

[28] HU OSA 300-10-2-76. "Cost cuts 47,000 million," *Večernji list*, November 12, 1965, 5.

[29] HU OSA 300-10-2-76. "Electricity lagging in Yugoslavia," *Radio Beograd*, November 22, 1965, 7.30 p.m.

[30] HU OSA 300-10-2-76. M. Petkov, "Production of coal," *Privredni pregled*, June 16, 1964, 2.

[31] HU OSA 300-10-2-76. D. Nikolić, "Electrochemical combine to build its own power plant," *Borba*, October 8, 1965, 6.

[32] D. Nikolić, "Elektroprivreda pripremila ključ 'Jugohromu,' *Borba*, March 14, 1968, 5; Danilo Vuković, "Renomirana fabrika na budžetu," *Borba*, March 9, 1969, 5.

continuous problem. Miners simply found work in other, more stable and profitable industries. Due to a lack of profit, coal mines could not invest in better equipment and work conditions to raise productivity, which only further aggravated the labor problem. In addition to that, besides thermal power plants, the inclusion of small thermal power plants in the electricity generating system put further pressure on coal mines and a similar pressure came from the general population in the rapidly growing cities. Finally, even opening new mines was not a quick solution to these grievances because the process required at least five to six years until a mine would become fully operational, while it was very difficult to attract and train additional labor power that was already in shortage. The outcome was that, despite the voices among experts in the field that coal was a fuel without a future, more and more it seemed that it would 'continue to be a basic fuel in Yugoslavia for a long time.'[33] On the other hand, due to such unfavorable conditions, the production of coal in the country actually fell in the next couple of years, while the shortage of miners grew to over 8,000 by 1965, despite the growing demand.[34]

Reacting to such challenges and taking into account the instability in electricity generation and delivery throughout the year, some coal mine managers resorted to the construction of small thermal power plants (TPPs) within their complexes. These plants could support mine operations as the main consumer of coal, while also ensuring a stable supply of electricity, necessary for continuous coal production. This happened in one of the biggest coal mining collectives in Yugoslavia, the *Kreka-Banovići* mines (Bosnia and Herzegovina). In 1965, they directed their limited profits into the construction of their own TPPs in several stages, expecting them to power not only the coal production, but also other industries and households in the region, to alleviate problems in seasonal lack of demand for coal and make additional profits from selling of electricity. Even though it sounds like a decent strategy in the given circumstances, this plan only further drained the investment funds of the mines in the next couple of years that were necessary for the modernization of the production of coal, workers' protective equipment and better working conditions in general, eventually only further aggravating problems that the strategy attempted to solve.[35] The situation was similar in the Istrian coal mines (Croatia) that produced coal with the highest calorific value in Yugoslavia. Due to delays in the construction of Plomin I and Plomin II TPPs, the management was forced to fire up to 2,000 miners in 1966/67 alone, simply because they could not sell their coal, and such a situation was expected to last well into the 1970s.[36]

The problem was acute and could not be easily solved, although there were good and bad years for coal mines, mostly depending on the hydrological situation, especially considering that not all mine managers could implement the strategy of *Kreka-Banovići*, even if it proved to be successful.[37] Reports from 1977 show that in the previous year, 'the miners worked day and night to meet the needs of thermal power plants,' while in 1977, due to continuously favorable conditions for electricity production in HEPPs, thermal power plants were 'in reserve.' Without the main consumer, coal mines struggled to sell coal on the market, ending in yet another vicious circle of profits and labor loss.[38] As early as 1978, coal mines experienced two years of negative balance, which caused the management of many mines to abolish the miners the so-called 'hot meal' addition to miners' salaries, along with other benefits. Coal mines working directly for different thermal power plants fared much better, primarily because their losses were covered by the electro-energy sector during periods of low demand for coal. As expected, these additional

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[33] HU OSA 300-10-2-76. M. Petkov, "Production of coal," *Privredni pregled*, June 16, 1964, 2.
[34] HU OSA 300-10-2-76. "Coal production falling off," *Ekonomska politika*, September 18, 1,259.
[35] HU OSA 300-10-2-76. "Construction of thermal electric power plant," *Borba*, June 23, 1965, 5.
[36] HU OSA 300-10-2-76. "Istrian coal mines to reduce production," *Privredni pregled*, January 15, 1967, 9.
[37] "Termoelektrana Tuzla," *EPBIH*, https://www.epbih.ba/stranica/termoelektrane, accessed on June 15, 2024. The construction of the TPP Tuzla was finalized in stages, as envisioned in the original plan, in the period between 1964 and 1978.
[38] HU OSA 300-10-2-76. S. Spasojević, Lj. Milanović, "Nema ugalj ko da gori," *Novosti*, September 12, 1977.

costs were compensated by an increase in electricity prices, which were eventually transferred to end consumers, industry and households, causing problems in the entire economy, such as inflation or lack of competitiveness of industrial products on foreign markets.[39]

Yugoslavia obviously had problems in balancing electricity generation from different sources, more precisely, hydro and thermal power. The previous analysis suggests that most of these problems stemmed from inadequate planning, a continuous rise in demand from industry and households, fluctuating seasonal weather patterns, delays in finishing new production facilities, and the lack of an adequate country-wide high-power electric grid capable of distributing electricity between different regions. Ultimately, however, one of the main problems was simple profit-driven calculations.

The beginning of 1967 showed very promising conditions for maximal electricity generation in Yugoslavia, and no restrictions were anticipated for the first time in many years. It seemed that the country had solved the problems of balancing different sources for electricity generation and that it would not be dependent on the 'disposition of heaven,' as sometimes bitterly commentated by the officials and daily press.[40] Spring rainfall was 10% higher than expected, causing the accumulation lakes of HEPPs to reach their maximum level. With the anticipated use of this water supply for electricity generation during the traditionally dry summer season, the accumulated reserves were estimated to be high enough to continue with normal production during the fall, when electricity consumption increases. By that time, additional rainfall was expected to quickly replenish the reservoirs. Hydrological conditions were so favorable that Yugoslavia was projected to export a surplus of electricity. In addition, new TPPs (along with several new HEPPs) were put online during the summer to compensate for any unanticipated disturbances in the electricity supply.[41]

However, by the end of October 1967, restrictions on electricity consumption 'in the whole of the country and for all electric current consumers' were raised once again, following the traditional pattern that favored households over the industry.[42] Officials also provided 'traditional' explanations, focusing on a dry season that extended into October, certain delays in putting new producing capacities online, necessary maintenance for several TPPs, and the inability to import more electricity due to a lack of surplus in neighboring countries as the main reasons for the restrictions.[43] These explanations did hold some truth, but they also hid the main reason.

The electricity price in Yugoslavia was higher during the summer for all consumers because the costs of production in TPPs that would generate more electricity during that period were estimated to be three times higher than in HEPPs. Considering that the accumulation lakes were overflowing with water, many electric power companies in the country opted for maximum production in HEPPs during summer to exploit the chance for higher profit margins, selling cheaply produced electricity at seasonal higher prices. Expectedly, such a strategy emptied artificial lakes by the end of the summer, but this was expected to be compensated by traditionally higher rainfall during the fall. This, however, did not happen, and the extended dry season forced several HEPPs to completely stop production right at the time when consumption started to rise. Furthermore, higher production in HEPPs during the first half of the year made already more expensive electricity generation in TPPs even less economical, forcing them to lower their production. Official estimates reveal that Yugoslav TPPs reached only 79% of the planned production, while in HEPPs it was 10% higher. Expectedly, this situation was transferred down

[39] HU OSA 300-10-2-76. M. Miljković, "Cene zamrzle zarade," *Novosti*, April 17, 1978.

[40] HU OSA 300-10-2-76. "The Committee for Social Plan and Finance discusses the building of power projects from 1966 to 1970," *Borba*, November 5, 1965, 4.

[41] HU OSA 300-10-2-76. Danilo Vuković, "Causes of electric power shortage," *Borba*, November 1, 1967, 4.

[42] HU OSA 300-10-2-76. D.V. "Restriction on electric current consumption in the whole of the country," *Borba*, October 31, 1967, 1.

[43] HU OSA 300-10-2-76. Danilo Vuković, "Causes of electric power shortage," *Borba*, November 1, 1967, 4.

the value chain, creating problems for coal mines that had to lower their production in the first half of the year, making them unprepared to quickly respond to higher demand by TPPs during the fall restrictions. Finally, putting all available capacities of TPPs to a maximum production caused breakdowns and further restrictions in the electric power supply.[44]

These problems continued to affect the Yugoslav electric power-producing sector in the following years but were gradually resolved through the introduction of new production capacities and a shift toward using fossil fuels (primarily coal) for electricity generation in TPPs, as shown in *Table 1*. Such a shift toward a predictable and continuous source of electric energy was to a certain extent anticipated and announced already in 1965, during a heated discussion in the Federal National Assembly:

> 'Under the present circumstances of an electric power shortage, it is of primary importance to secure, as soon as possible, larger and more reliable sources of electric power, which would not depend on the 'disposition of heaven' regarding weather or rainfall.'[45]

The change of the energy strategy and the switch to the use of fossil fuels for electricity generation was formalized in March 1975, during yet another season of nationwide electric energy restrictions. The strategy was titled the Social Agreement on the Basics of Development of the Electric Power Industry from 1974 to 1980 [*Društveni dogovor o osnovama razvoja elektroprivrede od 1974. do 1980. godine*], jointly adopted by the Federal Executive Council (federal government) and the Executive Councils of the Republics and Provinces on May 9, 1974. The document stipulated that the future development of the Yugoslav electric industry should focus on 'the construction of electric power facilities and coal and uranium mines for the needs of electric power industry (…) to meet the needs for consumption of electric power up to 1980.'[46]

SOCIAL CHALLENGES

Continuous restrictions in electric energy supply to the general population and households necessarily created many financial losses that are even more difficult to calculate than in the case of losses experienced by industry. However, it is also a fact that they were unavoidably transferred in all spheres of everyday life, to varying degrees. This is a particularly important problem to investigate considering that any disturbances in the living standards in a socialist country that promised equality and prosperity for the working class were a social ticking time bomb that should be avoided at any cost. The general pattern of electric energy restrictions in Yugoslavia confirms that the citizens' well-being was a primary concern for the policymakers, who readily and continuously sacrificed industrial production and the overall performance of the country's economy rather than the living standards of the general population. The problem is complex and obviously cannot be presented in zero-sum logic, yet due to limitations on the scope of the research presented in this paper, this chapter will explore only some of these social challenges with an aim to establish a framework for future research.

The continuously bad situation in Yugoslav coal mines was already explained in the previous chapter. Low salaries, outdated machinery, poor working conditions, and inadequate protective equipment were only a few problems experienced by coal miners in Yugoslavia that were directly related to disturbances in electric power production. High labor turnover also suggests higher migration of workers to other regions, which unavoidably produced social tensions on individual and regional levels. According to memories of one of the miners who worked in Istrian mines (Croatia), in his experience of 24 years working in mines, 42 miners were killed in accidents,

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[44] *Ibid*.

[45] HU OSA 300-10-2-76. "The Committee for Social Plan and Finance discusses the building of power projects from 1966 to 1970," *Borba*, November 5, 1965, 4.

[46] HU OSA 300-10-2-76. "Federation, republics agree on power policy," *Službeni list SFRJ*, No. 14, March 21, 1975, 355-358.

causing many of his colleagues to 'go home and never to return to the mine (…) they were afraid' (Matošević, 2007: 8). The problem was particularly hard for miners who had already established families and who were reluctant to abandon work in mines that promised at least some regular income. In other words, 'thanks to the [Istrian] mines, many families ate, but the mine also ate the miners, whether by damaging their health or by losing their lives deep inside the earth' (Matošević, 2007: 7). These challenges can be understood as universal for miners in general, although Istrian coal mines had an additional characteristic, high content of uranium in coal. For this kind of work, the miners never received any specialized protective equipment, training, nor any compensations for continuous exposure to this radioactive element, eventually leaving an invisible epidemiological trace in their local communities or regions where some of them moved to (Miljković, 2021: 366-368).

Yugoslav coal miners also suffered from the seasonal character of their work, predominantly because the biggest consumers of coal were TPPs. During regular weather conditions, the period from the fall to spring of the following year meant higher production and sales, while during the rest of the year, the mines usually struggled to sell their products. However, any irregular weather patterns would create either high or very low demand, often with devastating effects. During prolonged dry seasons, the high demand by TPPs usually led to extreme exploitation of miners through endless work shifts, or related accidents caused by a lack of safety measures in an environment that forced the production of coal at any cost. Under favorable hydrological conditions, TPPs would stop production and purchases of coal, making mine operations economically unsustainable. Even if everything returned to normal relatively quickly, it usually took up to two years for the mines to recover financially. These problems were eventually felt by the miners and their families, who suffered extended periods of pay cuts, with expected consequences for the quality of their lives and the entire community where they lived.[47]

The general population experienced different types of problems. Even though the Yugoslav authorities were doing their best to avoid restriction of electricity to households, they often had no choice, and such measures became somewhat regular. These restrictions usually amounted to roughly 10% of daily use for households. However, this was a statistical estimate, that excluded practical problems created by such measures. For example, the mere lack of balance between the production and consumption of electricity caused fluctuations in electric voltage and frequency. This was the main reason for the breakdowns of industrial machinery, but it was felt by common citizens as well. The first signs were the 'buzzing' of refrigerators and the infamous 'snow' on the image on TV screens, and breakdowns of these appliances were also a common thing.[48] Sometimes, these restrictions would be unannounced and last for several hours, usually during the period of the day when electricity consumption was the highest and consequently needed the most. That was the case in Belgrade in 1967, when whole parts of the city lost electricity between 5 p.m. and 9 p.m. Similar restrictions were observed in many other Yugoslav cities and towns.[49]

It would be impossible to calculate the actual losses caused by these restrictions, but it would be relatively easy to assume that besides immediate damage to households, it also had a devastating effect on the Yugoslav companies that produced electric appliances (*Ei Niš*, *RIZ Zagreb, Iskra*, *Rudi Čajavec*, *Gorenje*, *Obod*, *Sloboda*, etc.). At a time when their production and sales in the country accelerated rapidly, it would be reasonable to expect that they wanted to provide decent or even high-quality appliances to take a bigger share of the market. On the other hand, their appliances were designed for a rated and stable electric voltage and frequency, and obviously performed poorly in circumstances of restricted electric power supply, leaving them with myriads of problems, ranging anywhere between customer dissatisfaction, frequent warranty claims, and

[47] HU OSA 300-10-2-76. M. Miljković, "Cene zamrzle zarade," *Novosti*, April 17, 1978; Matošević, "Podzemna zajednica," 16.
[48] HU OSA 300-10-2-76. J. Brkić, "New restriction of electric power consumption," *Borba*, October 31, 1965, 2.
[49] HU OSA 300-10-2-76. "Many places in Serbia without electricity," *Borba*, October 24, 1967, 10.

impossibility to adapt production to unexpected, non-standardized and unpredictable circumstances.

During the 1966 restrictions, several companies that produced TV sets publicly expressed their concern and understanding for their customers stating that 'the TV set is a very expensive apparatus (…) and people are nervous when they cannot watch their TV program every evening.' However, they also emphasized that up to 30% of breakdowns during the warranty period were due to 'variations in the voltage of electric power grid.'[50] In other words, even if these companies could rely on a stable supply of electricity for their mass production of household appliances, regular country-wide restrictions had a significant, albeit incalculable, impact on their overall economic performance. These problems eventually funneled down to the general population and the quality of everyday life. Experiences from Bosnia and Herzegovina offer a glimpse into the everyday life under restrictions in electric power supply in Yugoslavia. During the 1970s, when the electrification of households exceeded 90% and the use of electric appliances was skyrocketing due to almost regular restrictions, the republican government was promoting ways how to spend free time without the TV set. The daily *Oslobođenje* encapsulated these contradictory circumstances in one of the articles published in February 1976, where it was suggested that 'the use of electric energy as one of the elements of the standard of contemporary people […] must be abandoned' temporarily.[51] Left in the dark and without the possibility to enjoy many of their hard-earned electric appliances and living standards they were rapidly getting accustomed to, the people were instead left agitated and forced to spend their slim savings on emergency repairs.

Restriction plans also included power cuts for street lighting, neon signs and shop windows, usually more often and for longer periods of time than for households. A recent study reveals that 'an immediate link between reduced street lighting and crime rates cannot be established, because no significant increase in crime rates could be noted in the revised literature,' but that any reductions in street lighting 'affects the behavior and perceptions of citizens,' primarily their fear of crime. On the other hand, the study shows that interventions on street lighting do have a direct impact on road safety (Struyf, Enhus, Bauwens, Melgaço, 2019: 28-29). Considering these results and the fact that almost no studies have been conducted related to the reduction of street lighting, it can be argued that the citizens in major Yugoslav cities necessarily experienced discomfort due to the rising fear of crime and related changes in behavior during restrictions of street lighting. The impact on road safety cannot be questioned, since it would be impossible to expect that Yugoslav drivers and their road behavior in conditions of poor street lighting were significantly different than in the rest of the developed world. In fact, due to the rapid development of motorization in the period analyzed in this study, it would be expected that the impact of reduced street lighting on road safety was even greater in Yugoslavia (Miljković, 2023: 280-308).

On the other hand, studies conducted in different areas of London and Chicago suggest that improvements in street lighting had a significant preventive effect on certain types of crime, such as 'violence against the person, vehicle crime, and harassment,' and it seems that this is particularly true regarding vehicle thefts considering that the absence of street light provide almost ideal setting for such a crime and close to zero possibilities for the victims to respond on time (Struyf, Enhus, Bauwens, Melgaço, 2019: 9; Chaflin, Kaplan, LaForest, n. a.: 30-31). For the purpose of this analysis, I will briefly mention only vehicle thefts, which saw a considerable rise during the 1960s and 1970s in Yugoslavia, and particularly the phenomenon of 'joyriders' (*pozajmljivači*; Miljković 2023: 296).[52] Joyriders appeared and quickly became a nuisance for

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[50] Stjepan Rajković, "Velike i 'male' brige zbog TV servisa," *Borba*, January 24, 1966, 6.

[51] "Štednja i reklama," *Oslobođenje*, February 9, 1976, 14. Quoted in Sarač-Rujanac, "Svjetlo u tunelu," 288-289.

[52] A joyrider can be described as a person who steals cars in order to drive around in them for pleasure, usually at high speed. They also represent a specific ritual of masculinity in which young males reaching adulthood are trying to compete with other more mature men who are in position to represent their

Yugoslav drivers and general traffic safety during this period, which neatly overlaps with the period of greatest restrictions in street lighting in major Yugoslav cities. Even though their appearance can be explained as a common phenomenon in societies that had reached a certain level of motorization, which happened in Yugoslavia roughly at that time (Miljković, 2023: 295-299), it may be argued that blackouts in the cities caused by restrictions in the supply of electricity contributed to the flourishing of these practices, at least to a certain extent. Following this argument, probably the same could be said about other petty crimes, such as street fights, robberies, and harassment, that only added to a general feeling of citizens' insecurity and perhaps outrage.

CONCLUSION

The European Green Deal aims to achieve an ambitious reduction in net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels, and zero emissions by 2050. An important component of this policy is the incorporation of higher shares of renewable energy to a minimum of 42.5% (and up to 45%) by 2030, almost doubling the existing share of renewable energy in the EU.[53] However, the main challenge in the use of renewable sources for electricity generation is their high dependence on weather conditions, more precisely, their variability and unpredictability that could potentially lead to intermittent energy supply and destabilization of the entire electric power system. Without the economically sustainable technology for mass electric energy storage, balancing the electric energy system based predominantly on renewable sources may prove to be challenging.

The Yugoslav experience with hydropower as a dominant source of electricity suggests that a high dependency on renewable resources will eventually lead to seasonal and temporary energy shortages and general system instability. While it can be argued that Yugoslavia did not enjoy a favorable renewable energy mix (solar, wind and hydro) like modern developed countries that could theoretically compensate for any seasonal disturbances in electric power supply, it is also true that the geographical distribution of the Yugoslav HEPPs was appropriate enough to benefit from different regional hydrological circumstances and provide adequate compensation. Yet, it did not happen.

One of the main reasons for that was the inability of Yugoslav authorities to construct and connect sufficient electricity-producing facilities to the power grid to meet the growing demand during periods of unfavorable weather and hydrological circumstances. In other words, while socialist Yugoslavia did enjoy enough electricity-generating capacities through most of its existence, even for export during good seasons, it struggled to construct enough facilities to respond adequately to varying seasonal weather patterns. This made any forecasting of demand and supply of electricity close to impossible, and restrictions in electricity supply a regular annual necessity. The relevance of the Yugoslav experience lies in the fact that, after the Second World War, the country was rapidly developing an almost non-existent electric energy power system. The EU Green Deal aims at a similar achievement. Although the EU electric power grid is in place, operational, and robust, which was not the case in Yugoslavia in the late 1940s, there is very limited historical experience with renewable energy, particularly regarding the expected rapid and radical shift to such sources, much of which still needs to be developed in the coming years. This adds additional significance to the Yugoslav experience. On the other hand, the EU also experiences significant delays in constructing new electricity generation facilities, such as huge solar power plants, mostly due to 'weaker wholesale electricity prices and problems getting

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masculinity through owning cars, among other things, as symbols of success in a society. Stealing a car for a joyride would make them symbolically equal to their mature counterparts, even if only temporarily.

[53] "Delivering the European Green Deal," *European Commission*, https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en#cleaning-our-energy-system, accessed on June 25, 2024.

permits and grid connections,'[54] a set of circumstances visible in the Yugoslav experience, despite significant differences in political systems and the sheer strength of the two economies.

For example, the recent and rapidly evolving trend of shifting towards electric vehicles will require a significant amount of additional electricity generation. Estimates suggest that if the entire fleet of German vehicles of roughly 45 million were powered by electricity, the demand for electricity would rise by roughly 20%. While this does not sound too dramatic, it is difficult to estimate with any accuracy not only what the actual rise in demand would be, but also the variability of the electricity demand in a rapidly changing car culture for which we do not have any historical data or experience.[55] Even though it will be possible to balance such changes through the rapid construction of additional electric power-producing capacities, adequate power grid, and innovative mechanisms for rapid response to changes in demand, this challenge presents yet another unpredictable and unknown value in this complex equation and it is easy to assume that not all of the EU countries will be able to respond to such a challenge adequately and rapidly.

The Yugoslav experience shows that reserve electricity-producing facilities could remain idle for extended periods, making their operational maintenance either difficult or very costly. These problems were transferred throughout the value chain, causing significant hardships to the workers in these facilities and related industries. Furthermore, Yugoslav companies operating HPPs were inclined to use their capacities to produce cheap electricity during favorable hydrological circumstances much longer than advisable in expectance of achieving high profits, only to experience that unpredictable weather conditions made their profit-oriented approach economically more damaging in the long run. The robust EU regulations could theoretically solve this problem with relative ease, but occasional, even if unintentional, mistakes in such calculations are still possible, especially when the economy, in general, is experiencing other unrelated challenges and when such a policy might be even favorable regarding the overall economic stability.

In fact, the first half of 2022 showed that it is possible to have a prolonged unfavorable hydrological situation, low winds and expected low solar power simultaneously, causing myriads of problems in demand forecasting, electric grid stability, and overall ability to adequately respond to such occurrences through the additional generation of electricity. Germany's experience provides a telling example. In addition to extraordinary weather patterns, the lack of natural gas in 2022, due to the Russian invasion of Ukraine, was an important reason for inadequate electricity generation. It also showed that unpredictable circumstances are possible and must be included in the plan to shift toward a predominant reliance on renewable sources, which are inherently unpredictable themselves. A similar situation occurred with the unexpected shutdowns of French nuclear power plants (NPP) for regular maintenance, which happened simultaneously, leaving German authorities unable to emergency import electricity. The solution was found in putting back online coal-fired TPPs in order to provide an adequate supply of electricity to consumers, both industry and households, and to secure grid stability. This decision was accompanied by continuous calls to households and industry for rational use of electric energy. Eventually, the use of coal-fired TPPs in Germany for electricity generation was prolonged up to March 2024, confirming that stable and predictable power-producing facilities are necessary for the stability of electric energy systems.[56]

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[54] "EU solar power growth expected to slow in 2024-25," *Reuters*, December 12, 2023, https://www.reuters.com/business/energy/eu-solar-power-growth-expected-slow-2024-25-2023-12-12/, accessed on July 3, 2024.

[55] "Is There Enough Electricity for Electric Cars?" *Go-E*, January 14, 2024, https://go-e.com/en/magazine/is-there-enough-electricity-for-electric-cars, accessed on July 2, 2024.

[56] "Germany reactivates coal-fired power plant to save gas," *DW*, August 22, 2022, https://www.dw.com/en/germany-reactivates-coal-fired-power-plant-to-save-gas/a-62893497, accessed on June 28, 2024; "Germany approves bringing coal-fired power plants back online this winter," *Reuters*,

The scenario that unfolded in Germany between 2022 and 2024, is very similar to Yugoslav experiences during the 1960s and 1970s, and so were the decisions of the German and Yugoslav authorities. In order to compensate for continuous disturbances experienced in this period in Yugoslavia, the decision was made to shift to a predictable and stable production of electricity in coal-fired TPPs. The EU Green Deal does not allow for such a scenario, leaving electricity generation in NPPs as the only technologically available alternative for achieving ambitious net zero CO_2 emissions by 2050.

However, the problem with NPPs is that they are 'generally inflexible and designed to run at constant power' (Freris, Infield, 2008: 22-23). In other words, and unlike TPPs, the electricity output in NPPs theoretically presents a constant in the electric energy grid, although periodical shutdowns for maintenance and fuel charge changes are advisable and necessary. More importantly, NPPs cannot provide an entirely variable supply of electricity in order to compensate for unexpected disruptions or peaks in production by facilities based on renewable sources. The French experience proves that such a balance is possible even with roughly 70% of electricity generated in NPPs. However, this delicate balance is achieved through the high price of electricity, a complex electric power grid system, and regulations that allow for emergency electricity export or import based on supply or demand changes. Additionally, significant reserve capacities, including coal-fired TPPs, are continuously maintained.[57] Nevertheless, establishing the right proportion between variable and unpredictable renewable sources and more stable sources of electricity that will most likely come from nuclear energy is an important open question that cannot be addressed in this paper.

The Yugoslav experience also shows that industry is particularly vulnerable to prolonged disturbances in electric energy supply. While in Yugoslavia it was possible to accept the financial losses caused by reduced industrial production that resulted in overall lower performance of the entire economy, it is highly unlikely that such a scenario would be acceptable for the EU as a whole and even more for individual companies. The 2022 electric energy supply crisis in the EU was transferred to the general population, contributing significantly to high inflation that lasted for almost two years. This caused significant damage to the economy, reduced living standards, and led to other related problems. In Yugoslavia, economic consequences were not felt as much by the general population, at least not directly or immediately, although the analysis presented in this paper reveals many multifaceted social and even psychological consequences that were as difficult to quantify as to solve.

While political challenges caused by inadequate electric energy supply in Yugoslavia were not discussed in this paper, predominantly due to specificities of the Yugoslav political system, they were present and added to the instability of the political system that eventually collapsed. Far from anticipating a similar scenario for the EU, it is astonishing that significant political challenges and changes have been experienced in the EU in the last couple of years, despite the rapid and adequate response to the electric power supply problems and the fact that they did not last for too long. However, the consequences are still felt two years later, mostly in the economic sphere, but also contributing to a rise of populist movements and political parties, at least to a certain degree. Anticipating that the weather patterns will be difficult to predict during the ongoing climate change, it can be argued that future disruptions in electric energy supply based on rapidly rising dependence on renewable sources will unavoidably happen more often, and that the right answers will be more difficult to find. Therefore, adequate preparation for such contingencies in the economic, social and political spheres would have to be a priority for the EU in order to avoid consequences that could be lasting, profound and impossible to solve at a later stage.

October 4, 2023, https://www.reuters.com/business/energy/germany-approves-bringing-coal-fired-power-plants-back-online-this-winter-2023-10-04/, accessed on June 28, 2024.

[57] "France Electricity Security Policy," *IEA*, June 30, 2022, https://www.iea.org/articles/france-electricity-security-policy, accessed on June 28, 2024.

Finally, even though Yugoslavia managed to find a proper energy mix based on the availability of energy resources that were specific for the country and adequate for that period, it took more than two decades for the system to function properly. It can be expected that the EU`s planning included in the Green Deal will be more robust than in the case of Yugoslavia. However, the shift in energy mix is expected to move towards unpredictable electric energy sources, having a significant potential for unexpected disturbances and disruptions in electric energy supply. Nuclear energy seems to be the only currently available technical solution, and even though it can be considered 'green' energy, at least regarding their zero CO_2 emissions, wider incorporation of NPPs into the energy mix will present additional environmental problems that will necessarily have to be addressed in the near future.

ACKNOWLEDGEMENTS

The research to this article was partially sponsored by Közép-Európai Egyetem [Central European University - KEE] through the Visegrad Scholarship at Blinken OSA Archivum in Budapest (https://www.visegradfund.org/apply/mobilities/fellowship-at-osa/). The theses explained herein represent the author's own ideas and do not necessarily reflect the opinion of KEE.

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Article history:	Received: 13.7.2024.
	Revised: 26.9.2024.
	Accepted: 26.11.2024.