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Energy consumption at asphalt plants in Slovenia, reduction of emissions and costs

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ABSTRACT

This article focuses on the topic of energy consumption, emissions reduction, and cost optimization at asphalt plants in Slovenia. It was discussed within the context of the Asphalt 4.0 expert committee of the Slovenian Asphalt Pavement Association.

Given the current instability in energy prices and the need to fulfil environmental policy objectives, the issue of energy consumption and emissions reduction at asphalt plants is crucial. Data was collected on annual energy consumption and asphalt mixture production from five different plants in Slovenia, with production volumes ranging from 50,000 to 200,000 tons of asphalt.

The analysis revealed that the average energy consumption for asphalt mixture production ranges between 60 and 100 kWh/t. Furthermore, there is a significant variation of 40 per cent in average energy consumption between the most and least efficient plants. The Asphalt 4.0 expert committee concluded that there are ample opportunities for energy optimization and emissions reduction in Slovenian asphalt plants.

The presentation highlights the availability of new concepts and green measures in the asphalt industry that can effectively reduce energy consumption, and CO2 emissions, and promote circular economy practices. The implementation of these concepts and technologies, supported by international tools and knowledge, will enhance productivity while minimizing the carbon footprint. Ultimately, these efforts will contribute to the construction of more durable, safer, and environmentally friendly asphalt surfaces.

This presentation emphasizes the importance of adopting innovative approaches in the asphalt industry to achieve sustainable and efficient practices by addressing energy consumption, emissions reduction, and cost optimization.

Keywords: Asphalt 4.0, Energy consumption, Emissions reduction, Cost optimization, Asphalt plants, Energy efficiency, Environmental policy objectives, Circular economy, Green measures, Carbon footprint, Durability, Safety, International tools and knowledge

1. INTRODUCTION

The Asphalt 4.0 expert committee of the Slovenian Asphalt Pavement Association addressed the topic of energy consumption and emission production at asphalt plants in Slovenia. The subject is relevant due to the current uncertain conditions in the energy market and the strive to reduce the industry's negative impacts on the environment.

Slovenian Asphalt Pavement Association strives to advance the Slovenian asphalt industry towards technological progress, and the utilization of new technologies and knowledge, all in the light of sustainable development and efficiency.

With this goal in mind, a literature review and discussion were conducted regarding the impacts on energy consumption in plants, which is closely linked to environmental emission production.

The analysis results revealed significant differences in average energy consumption among different Slovenian asphalt plants. The task indicates that it will be necessary to modernize some outdated asphalt plants and renew technologies in asphalt production.

2. ADVANCING SUSTAINABILITY IN THE ASPHALT INDUSTRY: ADDRESSING ENERGY CONSUMPTION AND EMISSIONS CHALLENGES

As is well known, one of the characteristics of the asphalt industry is its high energy consumption, leading to a significant amount of CO2 emissions during the production of asphalt mixtures. Energy consumption in asphalt mixture production is closely tied to the generation of emissions. With the growing emphasis on reducing energy consumption, lowering CO2 emissions, and promoting a circular economy, the asphalt industry will need to embrace new concepts and green measures. Utilizing international tools and insights, to increase productivity and reduce emissions, will be essential for practical implementation.

The introduction of new concepts and technologies will create the conditions for constructing more sustainable, safer, and more comfortable asphalt surfaces with the lowest possible carbon footprint.

2.1 Energy consumption optimization

In asphalt production, the largest share of energy, approximately 90%, is consumed by the drying and heating of aggregates. The remaining 10% of energy is used for heating bitumen tanks, machinery operation, and lighting. Measures that impact the reduction of energy consumption and emissions in plants include using dry aggregates for asphalt mixture preparation, lowering asphalt production temperatures (e.g., using warm mix asphalt), and optimizing the energy use of the asphalt plant.

During discussions in the Asphalt 4.0 committee meetings, company representatives shared their experiences from their asphalt plants, and we also reviewed data presented in the literature.

Reduction of Aggregate Moisture Content

Practical experiences from Slovenian plants and references in the literature indicate that aggregate moisture content is a crucial factor significantly affecting energy consumption in asphalt production.

Fine fractions, such as sand (0-2 or 0-4 mm), and reclaimed asphalt pavement (RAP) must be particularly well-protected from moisture and weather influences, especially rain. RAP should be processed during dry weather conditions. Bueche and Dumont (2012) state that when heating 0/2 mm sand containing 5% moisture, 54% of the energy is used for water evaporation and the remaining 46% for sand heating.

Reducing aggregate moisture content by 1% can lower energy consumption by 3.5% to 10% (even up to 15%), with most of the energy during asphalt production being consumed by water evaporation present in the aggregate (Evjen, 2018).

The gathered data from the literature aligns with calculations regarding the impact of moisture reduction on energy consumption, as prepared at one of the Slovenian plants, demonstrating the justification for new investments.

Impact of Temperature on Energy Consumption

In practice, we often discuss aggregate heating, but rarely do we talk about the temperature at which the aggregate needs to be heated. Heating the aggregate to 200°C compared to heating it to 170°C makes a significant difference in energy consumption. As an example: Lowering the temperature by 30 K, with the same production quantity (100,000 tons of asphalt mixture), results in savings of around 70,000 Liters of fuel oil per year (Evjen, 2018). This translates to 70,000 EUR or 1.4% of an asphalt plant's revenue at an average price of 50 EUR per ton of asphalt mixture.

Bueche and Dumont (2012) analyzed the initial and final aggregate temperatures and reached the following conclusions:

An initial aggregate temperature of Tz = 5°C increases energy consumption by 3% compared to the reference case, where the initial air temperature was Tz = 15°C.

An initial aggregate temperature Tz = 25°C reduces energy consumption by 3% compared to the reference case.

Increasing the final aggregate temperature by 25°C (180°C) requires 12% more energy than the reference case (155°C).

Heating the aggregate to 210°C increases energy consumption by 26% (reference final temperature 155°C).

Lowering the production temperature of the asphalt mixture by 10°C results in energy consumption savings of 3 to 4% (Evjen, 2018). When considering the possibility of reducing the production temperature, it's essential to examine each case individually (Evjen, 2018). The decision regarding the final asphalt mixture temperature is made by responsible personnel at the asphalt plant, who need to meet customer requirements and ensure the quality of the product. Therefore, employees in production plants must be aware of the impact of asphalt mixture temperature on energy consumption and the associated production costs.

An alternative to conventional hot mix production is warm mix asphalt production. Through specialized production processes, either by foaming bitumen or by adding additives to lower the asphalt mixture temperature, warm mix asphalt is produced. The installation technology for warm mix asphalt is similar to laying the hot mix asphalt, with the advantage of preserving bitumen quality, as there's no risk of bitumen "overheating." Lower temperatures subsequently reduce the amount of vapours (evaporations and aerosols), which, combined with lower temperatures, contribute to improved working conditions for workers. A 10K lower temperature translates to 50% fewer emissions, meaning that lowering the temperature by 20K results in only 25% of the initial emissions (EAPA, 2014).

Plant Efficiency

The reduction of energy losses is influenced by a variety of other factors, including energy consumption for heating bitumen tanks, energy needed for machinery operation, and lighting. In an asphalt plant, there are approximately 100 operational machines (which are typically older than 20 years in Slovenia due to ageing asphalt plants). These machines are used to power pumps, drums, conveyor belts, screens, exhaust fans, burner fans, elevators, mixers, and screw conveyors. Installing new, more energy-efficient machinery of IE4 efficiency class could lead to an additional 10% annual energy savings according to Evjen L. (2018). Positive impacts on energy efficiency can also result from investments in additional insulation (housing) for bitumen tanks and bitumen reheating systems in tanks (during low tariff periods). The role of operational staff in the plant is also significant; therefore, employees need to be continuously educated about energy consumption on the premises and its impact on plant costs.

Within the committee's activities, we collected data on the annual energy consumption of 5 Slovenian asphalt plants and calculated the average annual energy consumption for producing 1 ton of asphalt mixture (data are described in detail below). We compared the acquired data with literature data and found that the energy consumption data from Slovenian plants align with the energy consumption of plants mentioned in the literature. An analysis of the energy consumption of seven typical asphalt plants in Switzerland showed that the average energy consumption at their plants was 99 kWh/t (Bueche and Dumont, 2012). As an alternative to conventional asphalt production, the average energy consumption for producing a ton of warm mix asphalt was 63 kWh. Conventional production compared to warm mix asphalt production results in 25% to 47% lower energy consumption (Thives, Ghisi, 2017).

2.2 Analysis of Energy Consumption in Slovenian Asphalt Plants

Within the expert committee "Asphalt 4.0" of the Slovenian Asphalt Association, we collected data on energy consumption for asphalt mixture production from committee members for five

different production plants in Slovenia. For confidentiality, we've replaced the plant names with numbers. The discussed plants had annual production ranging from 50,000 tons to 200,000 tons of asphalt. The collected data on asphalt production and annual energy consumption for the years 2018, 2019, and 2020 are presented in Graphs 1, 2, and 3.

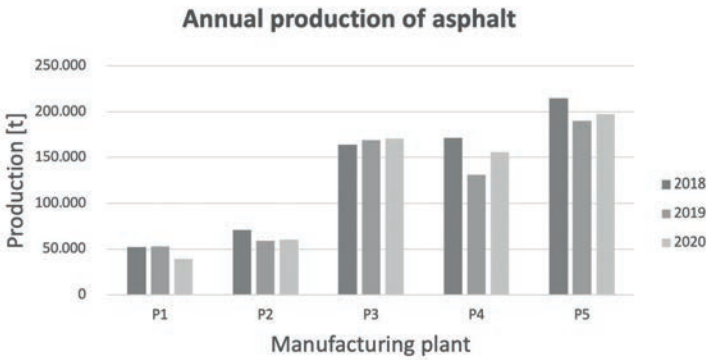

Figure 1: Annual production of asphalt for 5 Manufacturing plants in Slovenia

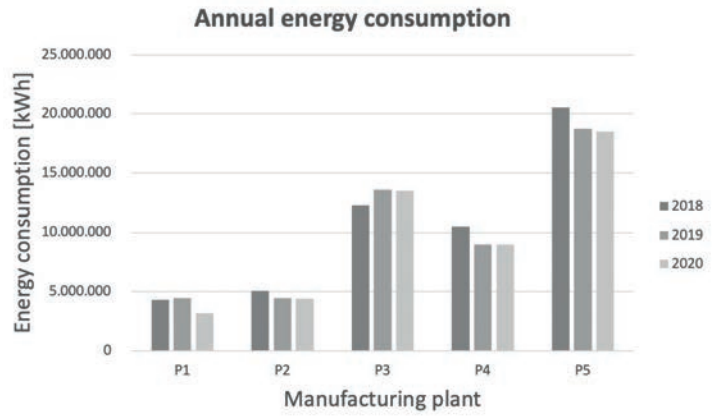

Figure 2: Figure 1: Annual energy consumption for 5 Asphalt manufacturing plants in Slovenia

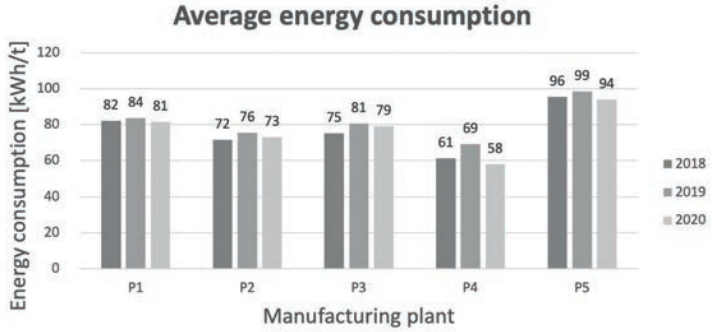

Figure 3: Average energy consumption for 5 Asphalt manufacturing plants in Slovenia

The analysis results have shown that Slovenian asphalt plants align with the average energy consumption for producing one ton of asphalt mixture as indicated in the literature (Thives, Ghisi, 2017), which ranges from 60 to 100 kWh/t. Additionally, it can be summarized that all the considered plants have untapped potential for optimizing their energy consumption.

The calculation of average energy consumption reveals a 40% difference between the most and least energy-efficient plants. After reviewing and discussing these findings with the committee members of "Asphalt 4.0," it has become evident that there are substantial reserves for energy optimization in asphalt plants across Slovenia.

2.3. Emission reduction

On average, an asphalt plant produces between 15 to 20 kg of CO2 for every ton of asphalt mixture manufactured (Evjen, 2018, Skoglund, 2019). This value pertains only to CO2 emissions from the asphalt plant, excluding emissions generated in other segments of the industry such as raw material extraction, transportation, and installation.

In the pursuit of responsible environmental stewardship and sustainable development, considering the carbon footprint of individual products in the market, including asphalt, will hold significant importance. It will be essential to establish a unified methodology for calculating the carbon footprint of laid asphalt mixtures, which key stakeholders involved in procuring asphalt services will need to incentivize or prioritize carbon footprint reduction appropriately.

The asphalt industry has developed new concepts, employed new technologies, and implemented measures to advance towards achieving the set emissions reduction target. Calculating the sum of emissions produced by the asphalt industry is highly complex; it requires considering all phases throughout the entire process, from raw material extraction, production, transportation, and installation to the usage phase, where the product's life cycle, including recycling and

potential reuse, must be considered. While most emissions are generated during asphalt mixture production, other factors should not be neglected. Emissions reduction in the asphalt industry can thus be influenced in various ways:

Use of Recycled Asphalt (RAP)

In today's world, with significant waste production, recycling has a special importance. Our task is to effectively utilize this option. The primary advantage of asphalt lies in its ability to be recycled into asphalt again, making it the only construction material allowing 100% reuse in high-quality new asphalt mixtures. Each kilogram of asphalt granulates used in new asphalt saves a kilogram of natural resources, aggregates, and petroleum products, thereby contributing to reducing CO2 emissions during the extraction of natural resources, their transportation, and positively impacting the cost aspect of asphalt mixture production. New asphalt mixture production technologies enable the use of up to 90% RAP in new asphalt mixtures while maintaining high-quality standards.

Lowering Asphalt Production Temperature

The significance of asphalt mixture production temperature goes beyond energy savings; it has a greater impact on emissions production. Technologies are available for producing warm mix asphalt. They reduce binder viscosity and enhance aggregate coating with binder even at lower temperatures. These techniques include foaming bitumen (with water or zeolite) and additive injection (e.g., waxes and paraffin). These methods decrease energy consumption and lower CO2 emissions while maintaining the same quality standards as conventional hot mix asphalt.

Reducing Aggregate Moisture Content

During asphalt mixture production, a high aggregate moisture content leads to significant energy consumption and emissions for evaporating the contained moisture, which is unnecessary when using dry aggregates.

Environmentally Friendly Energy Sources

The most energy-intensive plants are those that use electric energy to heat aggregate for asphalt mixture production. Research has shown that biogas, biomass, and pellets are much more environmentally suitable options, potentially reducing CO2 emissions by up to 90% (Skoglund, 2019). Using natural gas creates the least CO2 equivalent emissions compared to extra light heating oil and liquefied petroleum gas, reducing CO2 emissions by 24% when replacing heating oil with natural gas (Evjen, 2018).

Effective Organization and Logistic Management

Amid all these measures, it's crucial to emphasize that mutual coordination among all participants, effective organization, and logistics management throughout the entire process are essential in the asphalt industry. Transportation of asphalt mixture from the production plant to the construction site was often overlooked, but it has been found that this segment is crucial in the entire asphalt industry cycle, as it can lead to significant energy losses and affect the final temperature, quality, and performance of the pavement.

High-Quality Execution and Longer Pavement Life

The quality of pavement construction significantly impacts emissions production in the asphalt industry. Processes across all stages of the industry, from asphalt mixture design, laboratory testing, production in the plant, and transportation (ensuring minimal heat loss of the mixture) to proper installation and compaction, as well as adequate quality control, influence pavement quality. High-quality execution and installation extend the life cycle of the pavement construction. Every additional year in the life cycle of an asphalt pavement results in a 20% emissions reduction (Skoglund, 2019).

CONCLUSIONS

In conclusion, the asphalt industry has various creative and environmentally friendly ideas to cut energy use, reduce CO2 emissions, and move towards a circular economy. The key is to put these tools and knowledge to use, not only to boost productivity but also to reduce emissions that harm our environment while simultaneously achieving cost savings.

A detailed study of asphalt production temperatures in Slovenian asphalt plants has been beneficial for the industry in Slovenia. Comparing data has helped asphalt producers compete effectively. It's clear that outdated asphalt plants need renovation and more eco-friendly solutions should be adopted.

Moreover, within the Slovenian Asphalt Association, we are committed to driving progress within the asphalt industry. By uniting all stakeholders of the asphalt industry, our aim is to ensure that these innovations are not only theoretical but actively implemented in practice. Our goal is to make real changes, adopt new technologies, and balance innovation with sustainable asphalt production. We want those who support eco-friendly and innovative asphalt solutions to succeed in the market and stay competitive, which will also help the industry grow.

Embracing innovative concepts and technologies will lead to more durable, safer, and comfortable asphalt surfaces with a significantly reduced carbon footprint. This synergy between sustainable practices and asphalt production promises a greener and more prosperous future for both infrastructure and the planet.

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