The Most Sustainable Highway in The Netherlands

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Building the road to tomorrow.

The N470 project represents a significant achievement for the province of South Holland, marking the creation of the most sustainable road in the Netherlands.

This initiative stands out as a regular procurement within the electrical industry's existing framework, not merely a pilot or proof of concept. As the region's first fully CO2-negative roadway, the N470 is pioneering in its generation of self-sustaining energy for lighting and traffic signals, enhancing traffic flow and safety with innovative Direct Current (DC) technology.

The project's design prevents energy losses typically associated with long-distance, low-voltage AC transmission, thereby optimizing energy use and reducing CO2 emissions. A notable feature of the N470 is its Energy Wall, a dual-purpose noise barrier equipped with solar panels producing 75 MWh annually—enough to power a total of 323 light poles and 225 traffic lights, equivalent to the energy needs of about 26 households.

This comprehensive approach to sustainable road management sets a new precedent for infrastructure development in South Holland and beyond.

"We were able to operate the grid with 10% less energy than in a similar AC grid. It needs 40 to 60% less converters, 50% less wires, and 10% less PV and battery, to provide the same to the load."

- Sven De Breucker, Expert Advisor, Heijmans.

Goal

The aim of the project was to transform a provincial road into a CO2-negative entity, self-powering its lighting and signals, thereby reducing reliance on the public grid and advancing sustainability.

Action

DC Systems and partners introduced a pioneering DC microgrid for the N470, optimizing energy use and demonstrating DC's advantages for integrating renewable sources and enhancing efficiency at a large scale.

Solution

The N470 features an autonomous, direct current-powered local energy grid, utilizing solar energy and battery storage. This self-sustaining installation is operating under the Current/OS set of rules for seamless, efficient energy management.

Results*

- 10% reduction in energy consumption compared to similar AC projects
- 35% reduction in copper usage for cabling
- 10% downsizing of PV and battery installations
- 10% reduction in CO2 emissions
- 50% of energy needs covered from renewables

*Measured by Heijmans

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Transforming roadways into pathways of sustainability

The N470 project, spearheaded by DC Systems in collaboration with Eaton, SmartGrid, Heijmans, and other pivotal partners, marks a groundbreaking venture into the future of energy-efficient and sustainable road infrastructure. The N740 has set new benchmarks for innovation, resilience, and sustainability in the heart of the Netherlands.

A vision of CO2-negative infrastructure

In a bold move towards carbon neutrality, the Province of South Holland embarked on a journey with the renovation of the N470 roadway. This project was not just about enhancing road quality; it was a statement of intent to achieve a CO2-negative status across its entire length, pioneering a model for future infrastructure projects globally. The N470 stands as a testament to what is possible when innovation, technology, and sustainability converge.

Innovation in energy management

The project's hallmark is its innovative DC microgrid, a first of its size in Europe. This DC microgrid not only optimizes energy efficiency but also seamlessly integrates with renewable energy sources, namely solar panels embedded in the N470's noise barriers. These panels, along with a 1MWh battery storage system, ensure that the road's lighting and traffic signals are powered sustainably, day and night.

Achievements and impact

Energy efficiency:
The N470 project has demonstrated significant energy savings, using 10% less energy than comparable AC systems, thanks to the higher conversion efficiency in DC grids.

Resource optimization:
By adopting DC technology, the project achieved a 35% reduction in copper usage and a 10% reduction in the size of the PV and battery installations, underscoring the environmental and economic benefits of the initiative.

Sustainability milestones:
The project not only runs on 50% renewable energy annually, but also boasts a 10% reduction in CO2 emissions compared to similar AC projects, contributing to the global fight against climate change.

“The system is now three years in operation and we can say with certainty that it is fully functional, safe and reliable. We are proud as a province to have a lower environmental impact.”

- Jeroen de Jong, Advisor Traffic Systems, Province of South Holland.

Functions of the N470 installation:

- **Efficient power distribution:** The system efficiently distributes power across the entire 4.7 km stretch using only two sub-field cabinets and low voltage DC cables.
- **Renewable energy use:** The system seamlessly harnesses renewable energy through photovoltaic (PV) panels and energy storage with batteries, reinforcing the project's sustainability focus.
- **Power Availability:** Capable of islanded operation, the system maintains functionality even when disconnected from the public grid, due to the energy storage in the batteries.
- **Autonomous microgrid design:** The microgrid operates independently with distributed energy sources, managing power flow according to the Current/OS set of rules.
- **Cyber-security superiority:** Without the need for a communication layer, thus internet connectivity, the system is secure from cyber-attacks.
- **Commercially viable project:** This project operates within the commercial sector, setting itself apart from typical DC demonstrations or pilot projects.
- **Compliance with Dutch standards:** Developed in line with the NPR9090, the Dutch technical guidelines for DC installations, ensuring adherence to national standards.

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Technical specifications:

A total length of 30 km of distribution cables powering a 4.7 km distance in a distribution system of +700 Vdc with a ±60 Vdc droop control system and a sub-distribution light system of ±350 Vdc.

A TN-S earthing arrangement for stability and safety.

Solar panels are connected to the main distribution system via DC/DC converters, enabling efficient energy conversion.

Two 100kW isolated Active Front End (AFE) interfaces with the AC public grid, capable of operating at 50kW with limited line currents, ensuring continuous operation in islanded mode if necessary.

The entire 30 km of distribution grid is connected to a single 100kVA AC-grid-connection reducing the required AC-grid connections from 5 to a single AC-connection.

Designed to function within a broad temperature range (-20 to 50 degrees Celsius) and high humidity (95% at sea level), showcasing the system's robustness.

A 1MWh LiFePo4 battery array comprising 12 strings connected via DC/DC converters, with solid-state circuit breakers for protection.

Batteries equipped with an autonomous system communicate with the Battery Management System (BMS), adapting to the grid's state and the batteries' health and charge levels.

Streetlights across 23 strings operate at ±350V and are powered by DC/DC LED drivers, complete with power line communication control.

"The enduring impact of the N470 serves as proof of the longevity and resilience of sustainable development. By marrying simplicity in system design with complexity in its components, we've not only made sustainable development a present reality but have also redefined the benchmarks for energy and infrastructure resilience over time."

- Panos Kolios, R&D Lead, DC Systems.

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The streetlight system includes Residual Current Devices (RCDs) to protect against direct contact, leveraging the low DC leakage in cables to provide safety enhancements not typical in AC lighting installations.

The network is safeguarded by hybrid circuit breakers and solid-state protection mechanisms.

Overvoltage protection is built into the network to ensure overall network integrity.

Power flow and protection are governed by the Current/OS set of rules, which outline the operational requirements for the system.

Looking ahead

The N470 is more than just a road. It's a pioneering project that showcases the potential of DC technology in creating self-sufficient, sustainable infrastructure. With its successful implementation and the ongoing monitoring of its performance, the N470 serves as a proof-of-concept for future projects worldwide.

As we move forward, the collaboration between DC Systems, its partners, and the Current/OS Foundation continues to drive innovation in the field of smart DC microgrids. By offering an open set of rules and clear guidelines for grid management, we are laying the groundwork for the widespread adoption of sustainable energy solutions.

Conclusion

The N470 project is a landmark achievement in the realm of sustainable infrastructure, demonstrating the power of collaboration, innovation, and a shared vision for a greener future. As we celebrate the success of the N470, we also look to the horizon, ready to apply the lessons learned and the technologies developed to new projects, paving the way for a sustainable world for generations to come.

For more information about the N470 project and our future initiatives, visit our website or contact our team at DC Systems. Let's drive towards a sustainable future together.

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