see a progressive increase in SCR improvement, related with EGH power demand. From 65% FTPP onwards there is no remarkable efficiency improvement (<1%) of the catalytic system. Even for an EGH proposed of 0.5 kW, we can see that improvements in almost every FTTP can be dismissed. A poor efficiency improvement (5%-15%) is obtained for FTPP downwards until 50% for most EGH power values. However, EGHs of 0.5 kW and 1 kW are included totally in this improvement zone or even lower. The next efficiency improvement zone is more dynamic, which represents major values obtained adding few extra minutes of the ATEG recovery stage. Observing this medium improvement zone (15%-40%), we can conclude that includes low FTPP values (30%-45%). EGH power demand required for these improvements is in the range of 2 kW to 3 kW. The time needed to recover this energy through the ATEG is moderate (approximately 50-90 minutes). Moving on, we arrive to major recovery improvements (40%-55%). These figures can be obtained by EGH power values of 4 kW to 5 kW and can be applied for low FTTP values (30%-45%). Time figures for recovery stage of this power range are longer (95-155 minutes) but completely within HDV daily transportation routines.

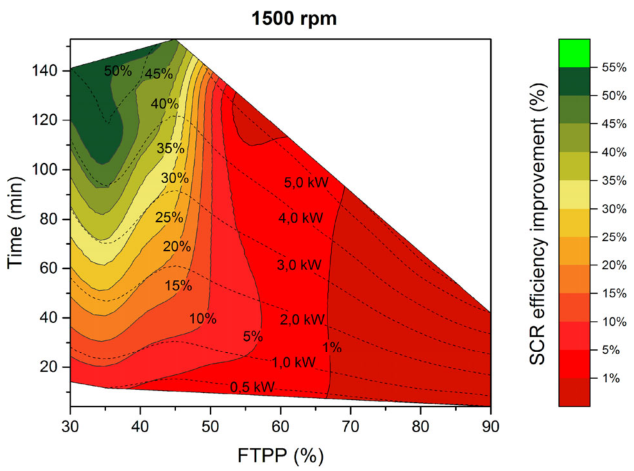

Figure 7. SCR efficiency improvement at 1000 rpm using different EGH power. Time using ATEG at 1500 rpm to supply respective EGH power demands at 1000 rpm.

4. Conclusion

This study experimentally demonstrates that the use of an EGH can reduce the NOx emissions more than 80% in a Diesel-powered Euro VI Heavy Duty truck working at low engine regimes. The highest reductions were achieved at 1000 rpm and medium FTPP values. It also has been demonstrated that, at low engine regimes, EGH power higher than 5kW does not produce a significant impact on NOx reduction. A conventional catalytic device heated using an EGH of 5 kW could improve the SCR efficiency from 65% to 95%. Consequently, exhaust gas heaters are a potential solution to the high emitting low engine regimes issue.

Numerical simulation of an ATEG demonstrate the viability of using the exhaust waste heat to produce electricity needed by the EGH. This ATEG generates a power range between 0.4 kW (at 30% FTPP) and above 1.4 kW (at maximum FTPP of 90%). These values are obtained using an average engine regime (1500 rpm) scenario.

The viability of energy supply during a cold start scenario (1000 rpm during 12 minutes) is positively demonstrated by time figures not exceeding of 155 minutes in the worst conditions (5 kW of EGH demand and generation at 45% FTPP). The EGH-ATEG allows the aftertreatment system to start dosing urea solution sooner. In consequence, the SCR efficiency is improved up to 55% using a proposed EGH of 5 kW, which is powered exclusively by an ATEG.

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