Hochschule Esslingen
University of Applied Sciences

Fakultät Fahrzeugtechnik
Prof. Dr. habil. Oliver Zirn

Hybridisation Potentials for Heavy Trucks Considering Route Topography

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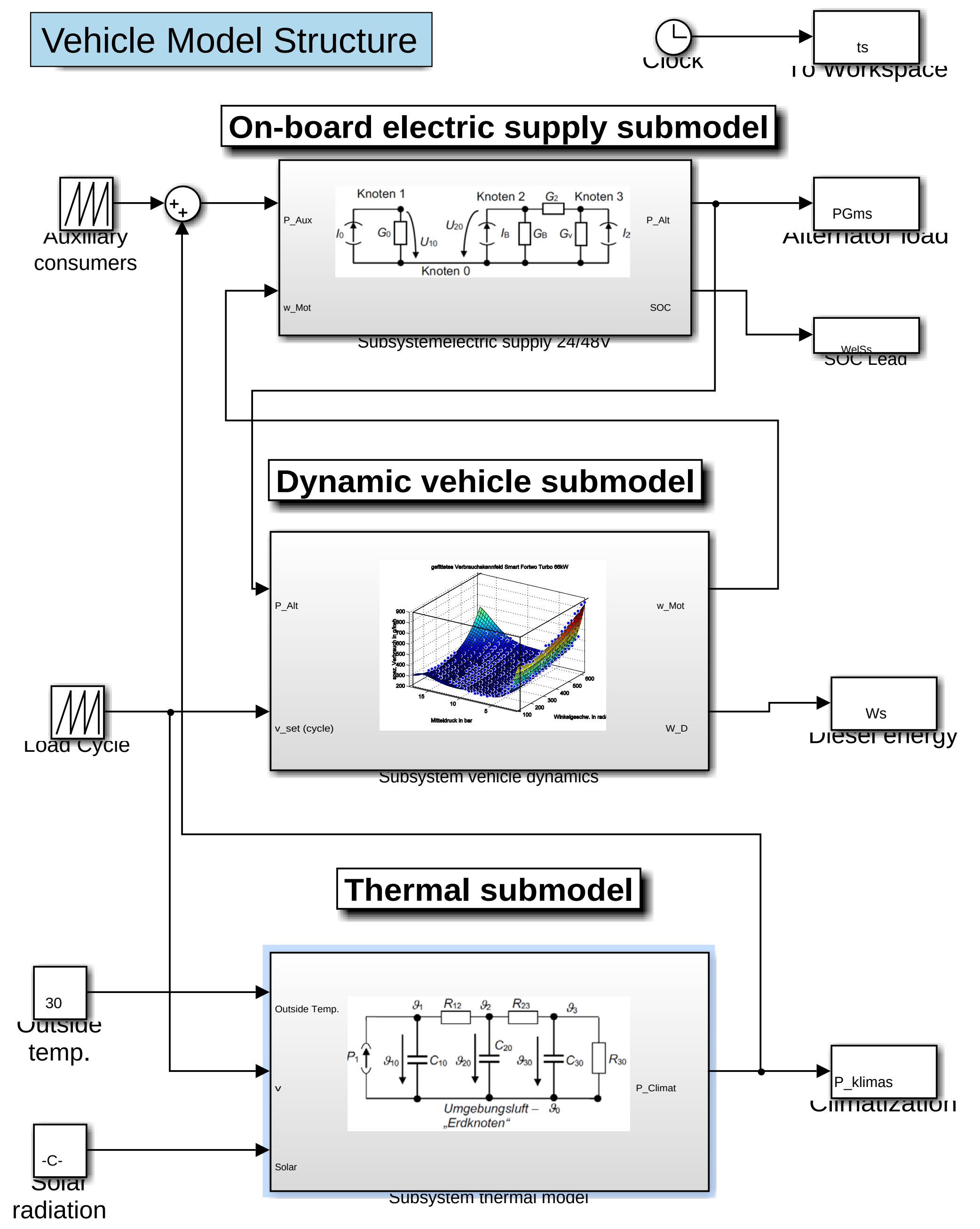
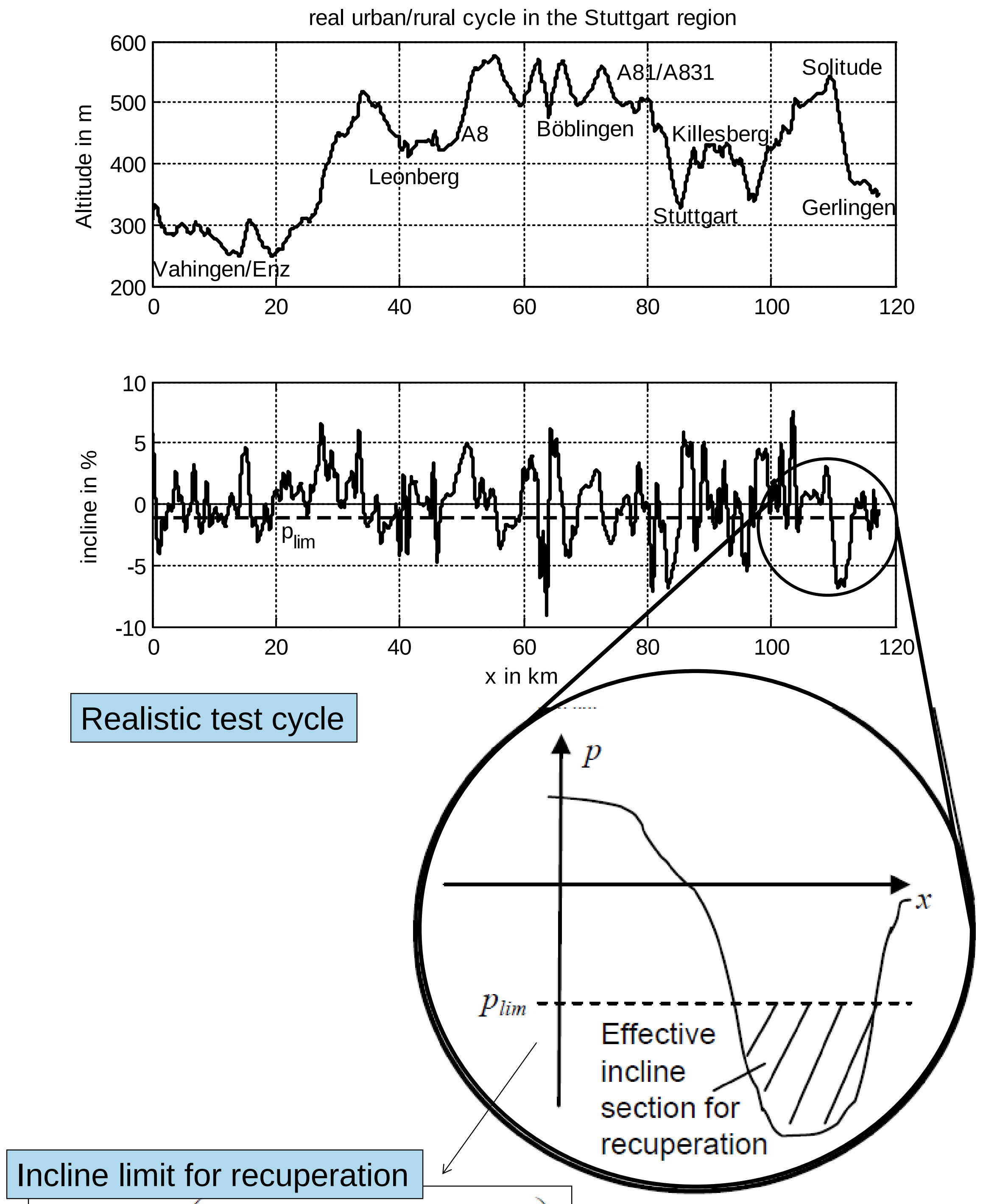
Based on dynamometer test cycles or plain motorway operation, heavy truck hybridisation must be considered as uneconomic if only the kinetic vehicle energy can be recuperated. In mountainous regions, micro hybridization by a 48V-belt generator or mild parallel hybridisation by a large high voltage electric drive can result in considerable fuel consumption savings as well as additional benefits for heavy load utility vehicles. Additional electric power and battery size are still critical design parameters as well as critical cost factors considering the limited space and depreciation time as well as the need for maximum payload. Based on vehicle model simulations, this contribution quantifies fuel consumption savings, recuperation energy harvesting and battery requirements for different truck sizes with test cycles based on realistic route topography. The main route topography parameter for the recuperation benefit is the effective incline that integrates all downhill sections that overcompensate the vehicle resistance by tire friction and air resistance. The simulation parameter studies lead to an analytical benefit estimation, based on load cycle parameters like effective velocity, effective incline as well as the vehicle parameters mass, drag coefficient and cross sectional area. Thus, the return on investment can be assessed by an analytic rule of thumb, based on tracked cycles of existing vehicles

Vehicle Model Structure





Realistic test cycle

Incline limit for recuperation

$$p_{\lim} = -\left(f_R + \frac{\rho \cdot cw \cdot A}{2 \cdot m \cdot g} \cdot v_{eff}^{\ 2} \right)$$

Analytical fuel saving potential based on load cycle data:

$$b_{rek}{}' = b \cdot \eta_G \cdot (\eta_M \cdot \eta_B \cdot \eta_{PE})^2 \cdot m \cdot \left[g \cdot \underbrace{\frac{c}{x} \cdot \int_0^x \begin{matrix} (p_{\lim} - p(\xi))d\xi \ for \ p_{\lim} > p \\ 0 \ for \ p_{\lim} < p \end{matrix}}_{effective\ drop\ height\ h_{eff}} + \frac{BE}{2} \cdot v_{eff}{}^2 \right]$$

Fuel saving potential depending on the installed electric power:

$$b_{rek,est}(P_E) = b_{rek}{}' \cdot \frac{(P_E/P_{E0})^{3/2}}{0.6 + (P_E/P_{E0})^{3/2}}$$

Mild hybridisation rated power:

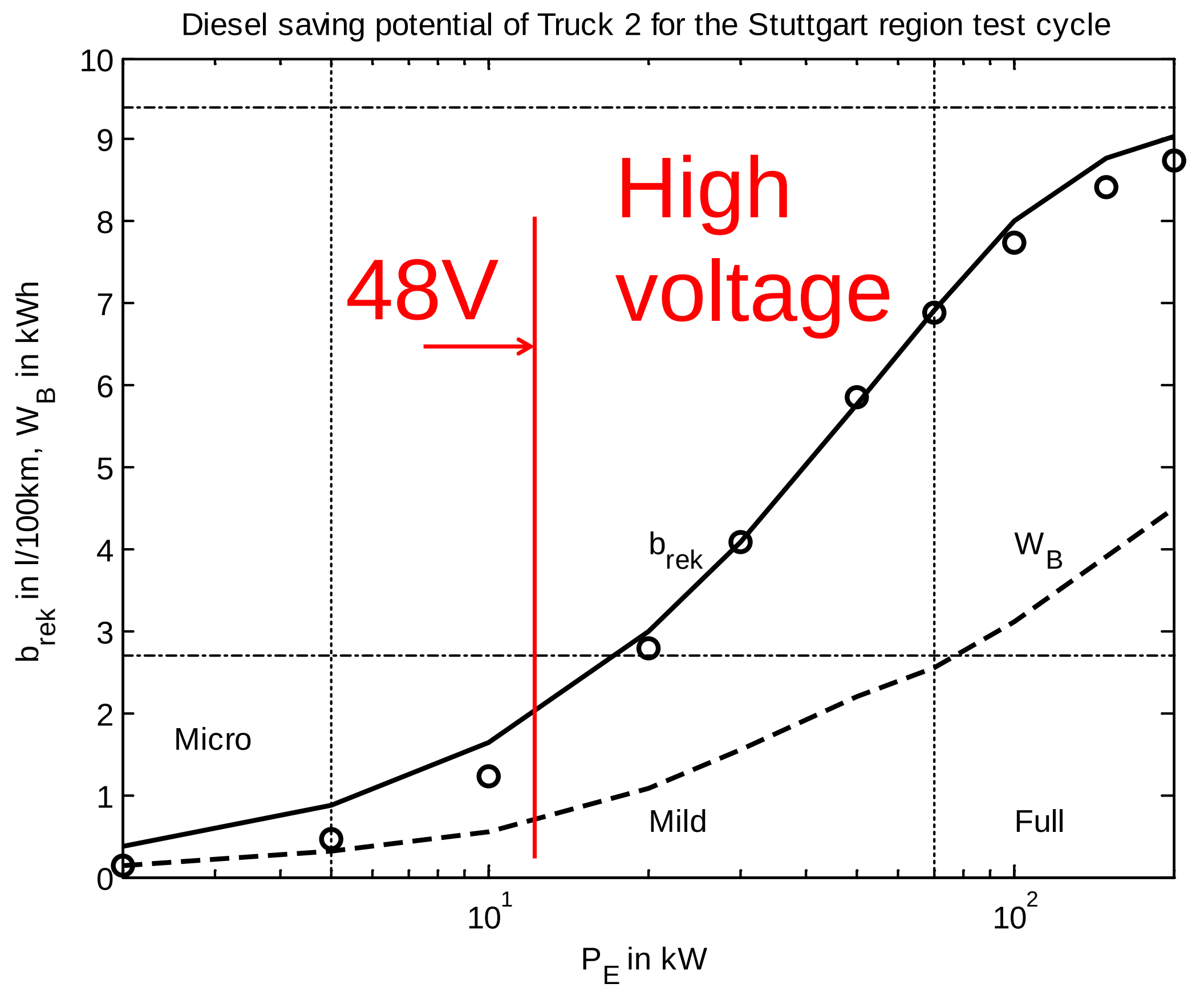
$$P_{E0} = m \cdot g \cdot p_{eff} \cdot v_{eff}$$

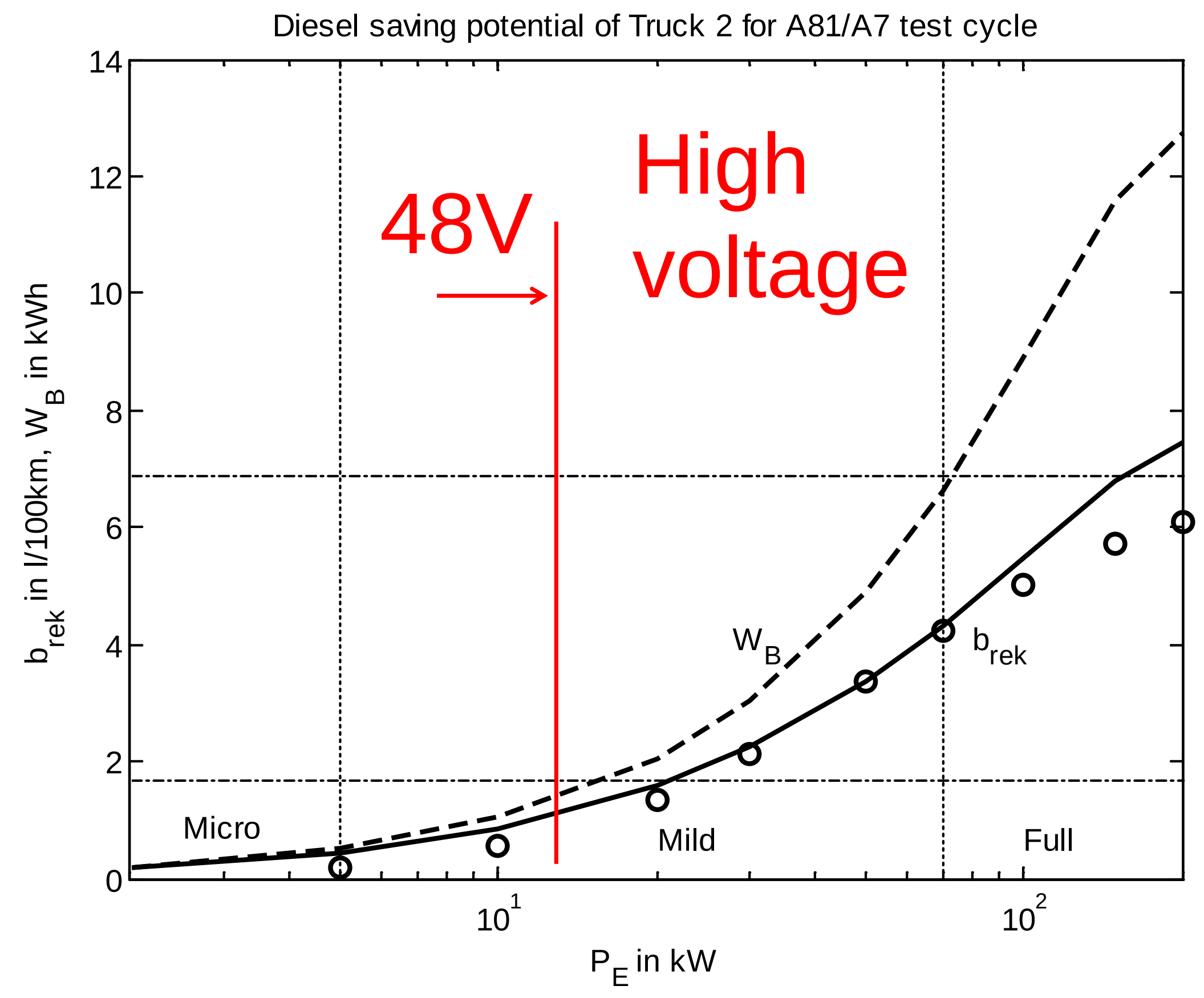
Effective incline of the load cycle:

$$p_{eff} = \sqrt{\frac{1}{x} \cdot \int_0^x \begin{matrix} (p_{\lim} - p(\xi))^2 d\xi \ for \ p_{\lim} > p \\ 0 \ for \ p_{\lim} \le p \end{matrix}}$$

Effective velocity of the load cycle:

$$v_{eff} = \sqrt{\frac{1}{T} \cdot \int_0^T v(\tau)^2 d\tau}$$





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