

High-Speed Railway Power Supplies

SC C6, PS1

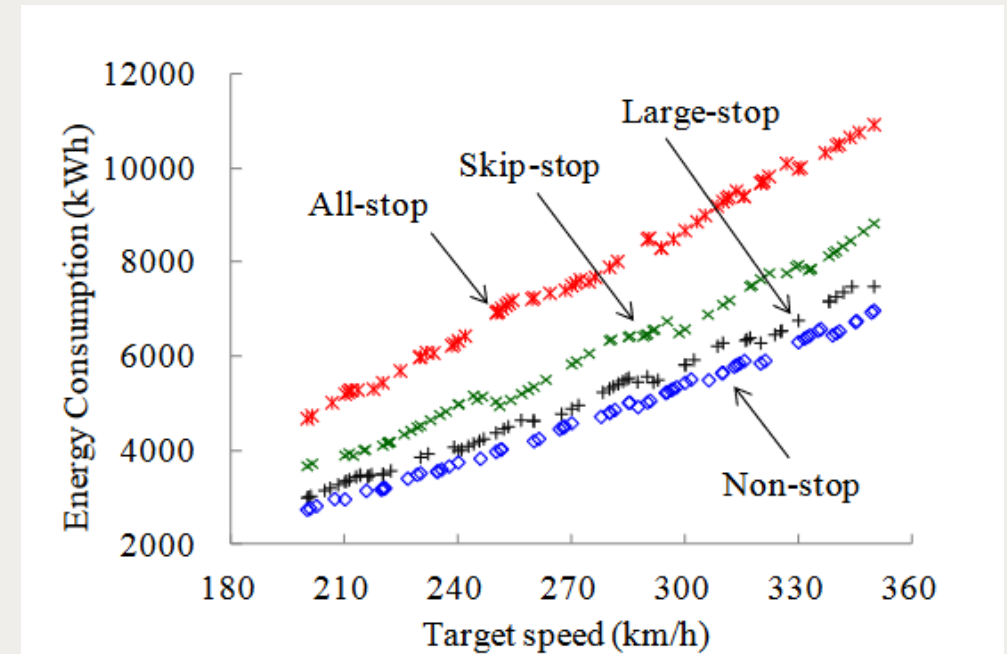
Question 1.4: With the development and the usage of high-speed trains, the requirements for load balancing arise. Is there a relation between the speed and the power that needs to be supplied? What are further considerations in relation to the power supply? Are there any opportunities provided by regenerative braking?

Philippe Maibach, Switzerland

HITACHI
Inspire the Next

Relation between the train speed and the supplied power

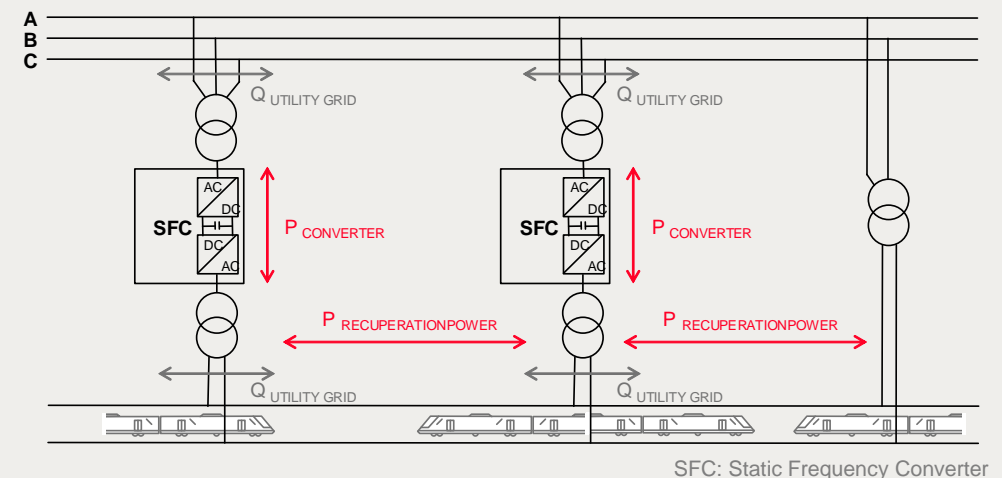
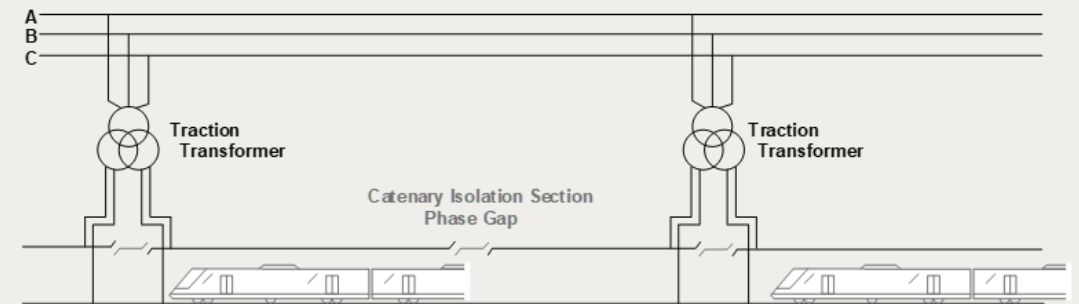
- Consumed energy depends on
 - Train mass, velocity ($\sim v^3$), friction
 - Topography: rail slope, tunnels
 - Train operation, e.g. number of stops
- Power
 - Losses of train and railway system
 - Acceleration (derivative of energy)



*Estimated energy consumption vs. top speed for the Shanghai-Hangzhou line. Numerical example.
Adapted from Feng, Sun, Liu, & Li (2014), Assessing Energy Consumption of High-speed Trains based on Mechanical Energy. Procedia – Social and Behavioral Sciences, 138, 783-790.
<https://mappingignorance.org/2020/01/22/the-limits-of-high-speed-rail/>*

Opportunities provided by regenerative braking

- Utilities do often not allow and/or remunerate regenerative braking energy
- Classical power supply systems
 - Regenerative braking due to neutral sections lost / not attractive
- Power supply systems with back-to-back converters
 - Very few neutral sections: Braking energy can be kept within the system



Group Discussion Meeting

Further considerations in relation to the power supply

- Using back-to-back converters
 - Fault current contribution from converters is limited
 - Consider protection concept as
 - Advantage when supply power needs to be increased
- Railway system design and operation very flexible
 - At three-phase PCC:
 - No unbalance
 - Unity power factor (or controllable power factor)
 - Pre-defined harmonic spectrum greatly independent from traction load
 - Grid code compliance
 - At single-phase catenary:
 - No / very few neutral sections
 - Voltage / reactive power control
 - Larger distance between feeding substations
 - Active power flow control
- Important to consider costs and benefits on system level

Group Discussion Meeting