



The Power Supply and Engine Simulation Program

轨道交通牵引供电仿真系统软件

北京星竹科技发展有限公司
德国IFB公司



电气化咨询工作 Consulting Tasks for Electrification

电气化系统电气方面的评估是咨询工作的主要部分

**The assessment of the electrical aspects of the electrification system is a
main part of consulting work.**



电气化的咨询任务 Consulting Tasks for Electrification

电气化的规模对以下有影响

The electrical dimensioning has influence on:

- 铁路供电的结构（变电所的配电和馈电段）
Railway power supply structure (distribution of substations and feeding sections)
- 导体类型的选择和部件的等级
Choosing of conductor types and rating of components
- 能耗
Energy consumption
- 接地条件，包括接触电压问题
Earthing conditions including touch voltage problem
- 沿线电磁兼容
Electro magnetic compatibility along the line

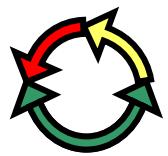


电气化的咨询任务
Consulting Tasks for Electrification

采用电气网络模拟系统：
Answers by
Electrical Network Simulation
with

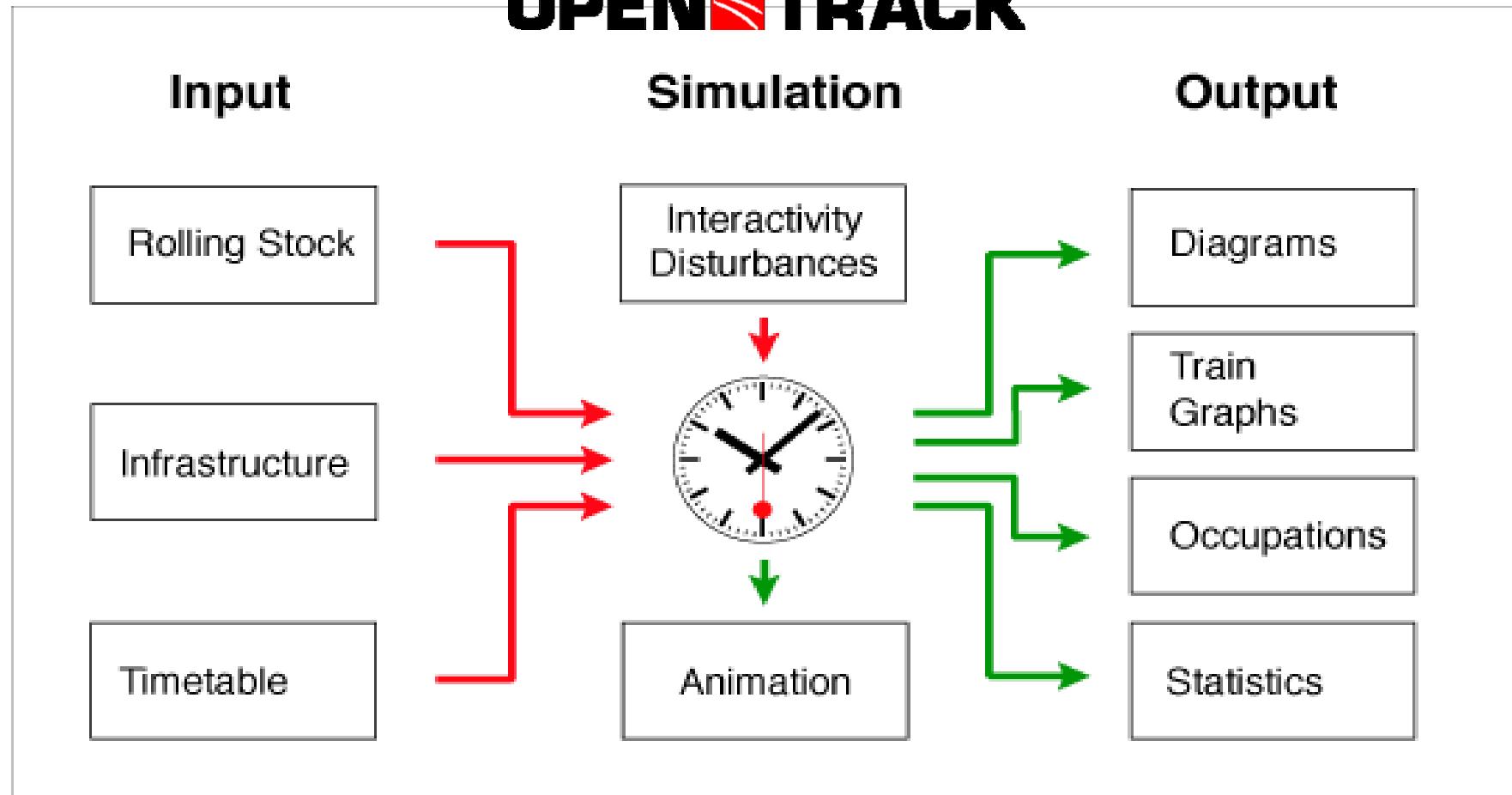
 **openPowerNet**

The logo is identical to the one at the top of the slide, featuring the text "openPowerNet" and a circular arrow icon.

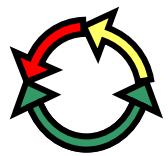


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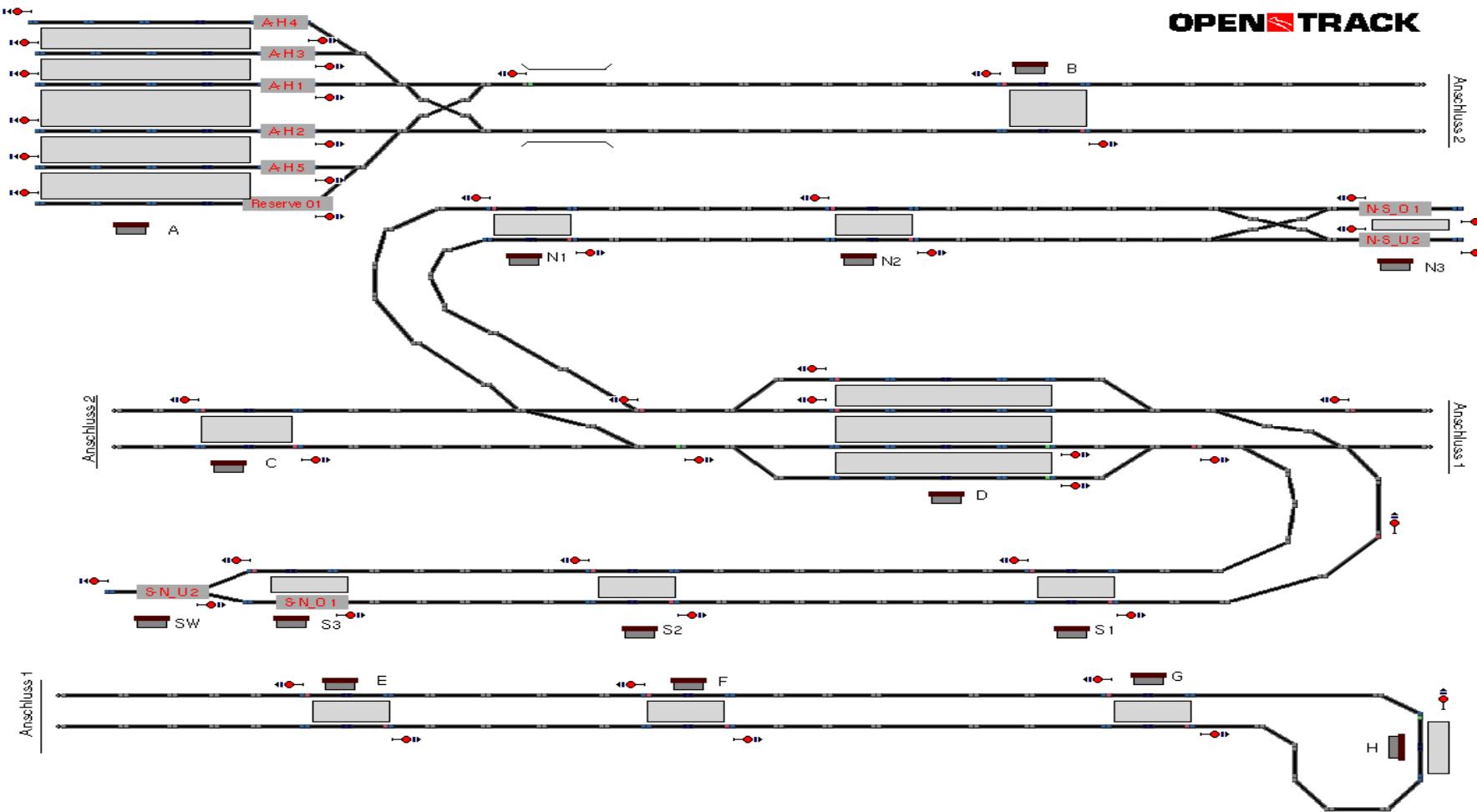


Source: ETHZ



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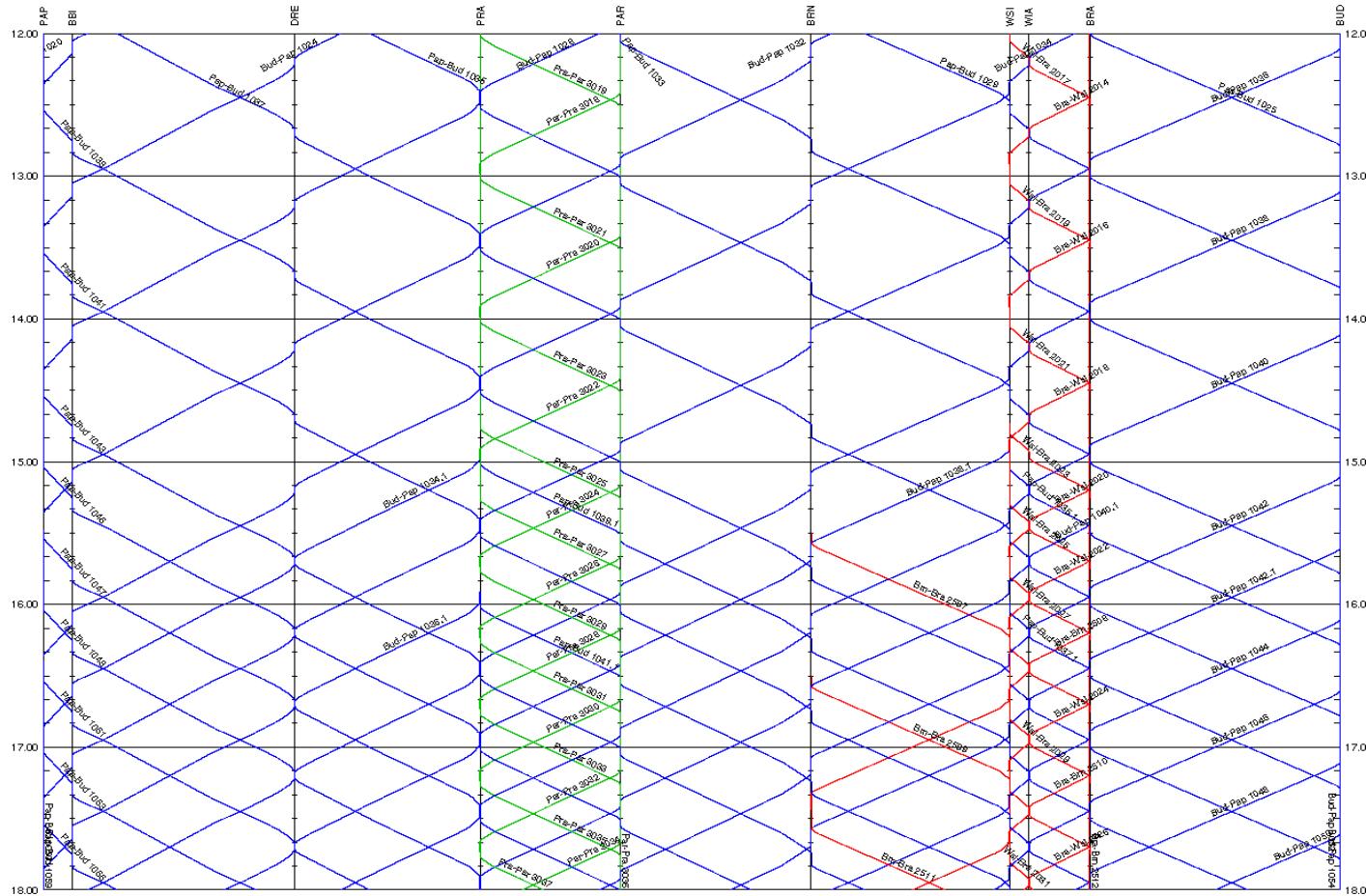




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Berlin Papestr. - Budapest



Source: IFB

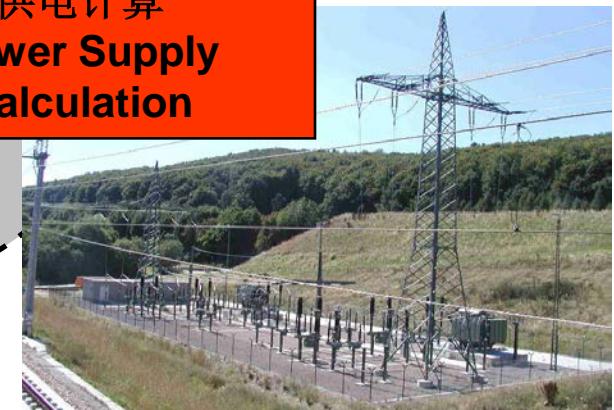
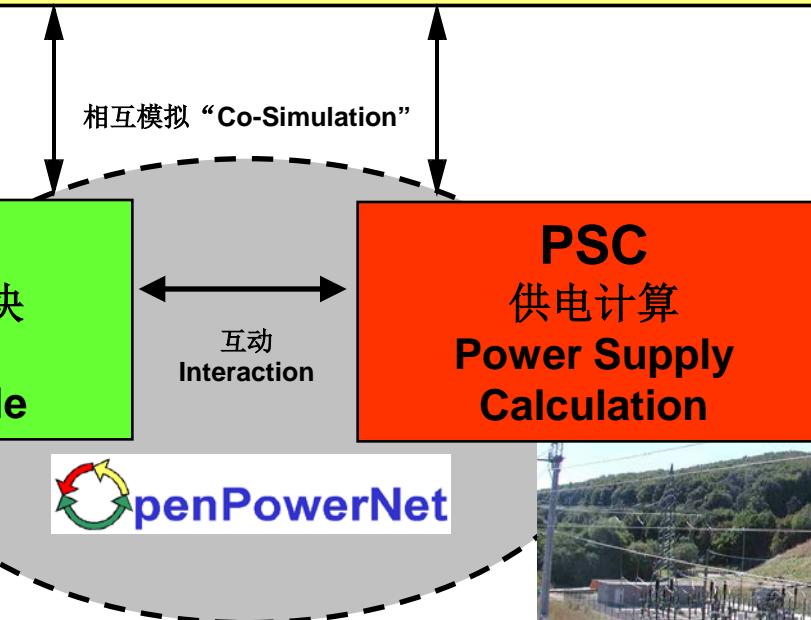


铁路运营模拟 Railway Operation Simulation

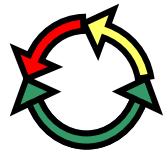
OPEN**TRACK**



牵引技术
Propulsion Technology



供电系统
Power Supply System

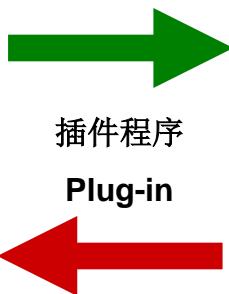


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模拟任务的区分 Separation of Simulation Tasks

铁路运营 Railway Operation

- 线路 Line routing and alignment
- 轨道布置 Track layout
- 信号系统 Signalling system
- 列车数据 Train data
- 时刻表 Timetable
- 连接条件 Connecting conditions
- 运营规则 Operating rules



负荷与能耗 Load Flow and Energy

- 列车牵引数据 Train propulsion data
- 电网参数 Power grid parameter
- 变电所布置 Substations arrangement
- 开关状态 Switch states
- 馈线和电缆 Feeder lines and cables
- 接触网系统 Catenary system
- 接地系统 Earthing system

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模拟结果 Simulation Results

- 列车运行图、行程和循环次数 **Train running diagrams, travel and circulation times**
- 列车供电和电流曲线 **Train power and current curves**
- 列车受电弓电压 **Train pantograph voltage**
- 电气设备的供电和电流特性 **Power and current characteristics of the electrical components**
- 接触线电压特性 **Overhead line voltage characteristics**
- 短路电流等级 **Short-circuit current level**
- 接触电压评估的轨对地电位 **Rail-to-earth potentials for touch voltage evaluation**
- 接触网系统的电流分配 **Current distribution in the catenary system**
- 预计的沿线电磁磁场 **Expected electro-magnetic field exposition along the line**
- 列车和馈电段的电力和能耗 **Power and energy consumption on train and feeder section level**

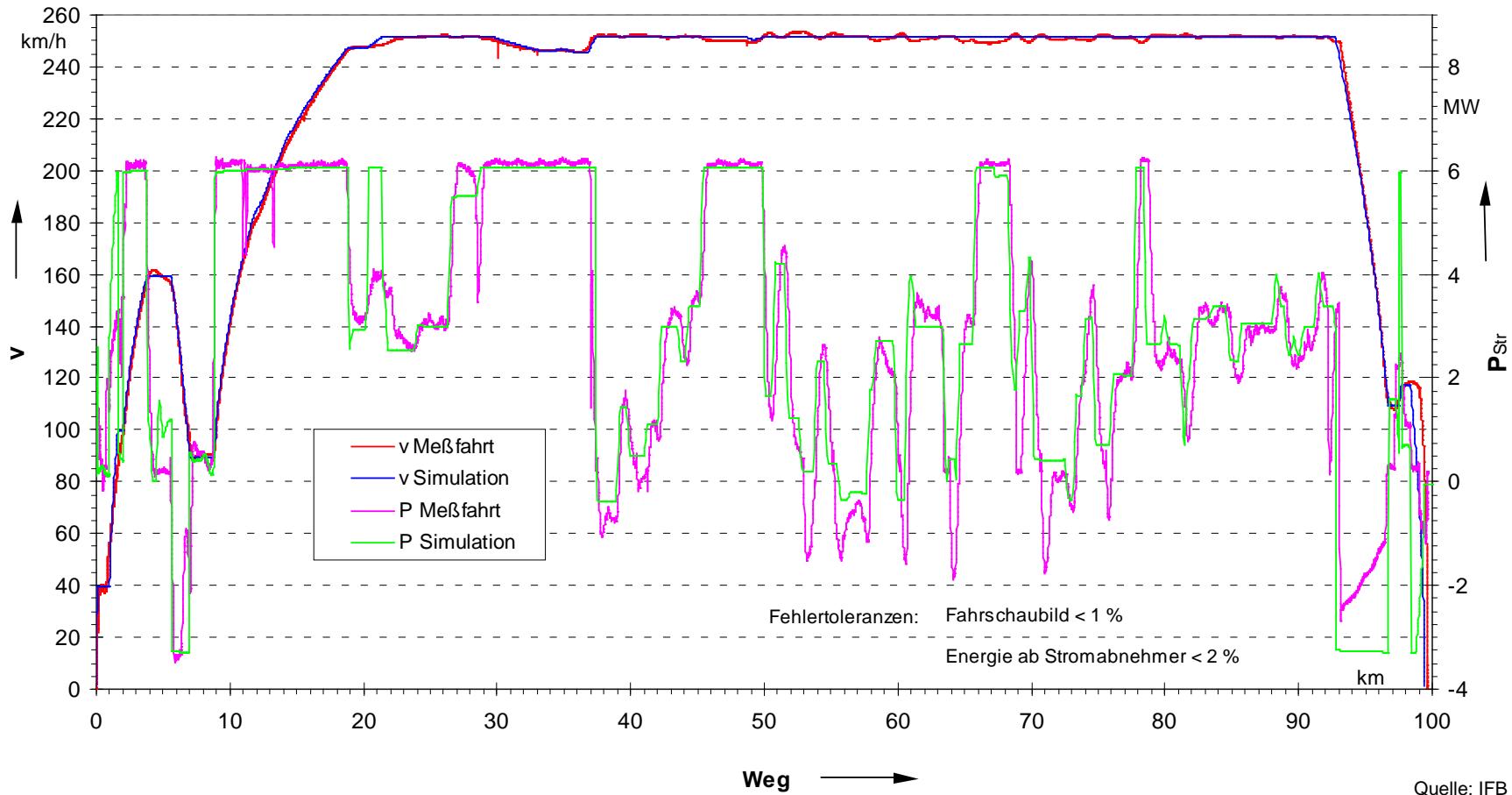


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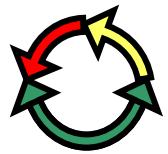
Train Speed and Power Characteristics

Measurement and Simulation Results

ICE1 Hannover – Göttingen



Quelle: IFB

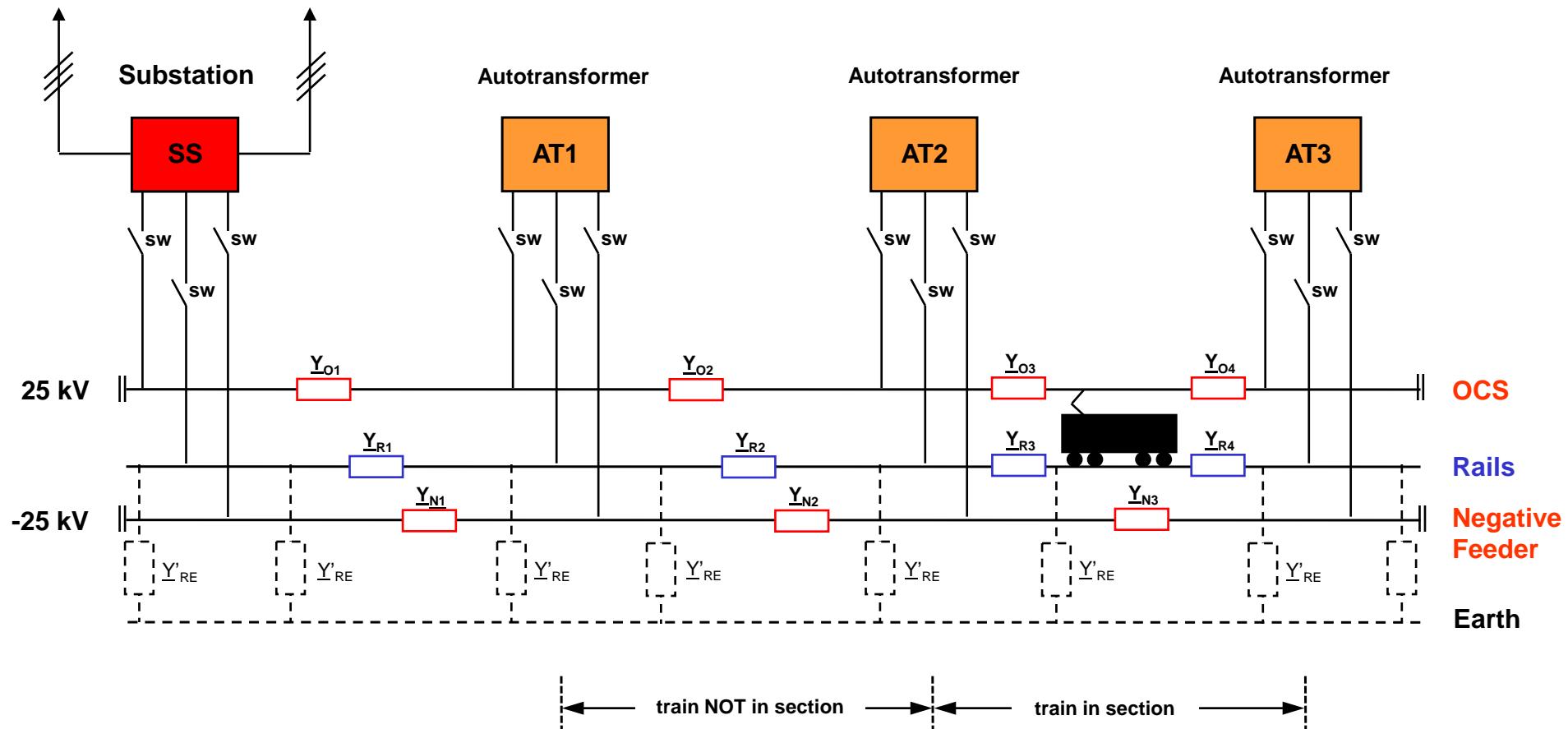


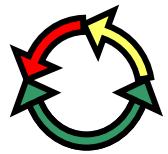
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Power Supply Network Structure (2 AC 25 kV ~ 50 / 60 Hz)

Power Grid Connection

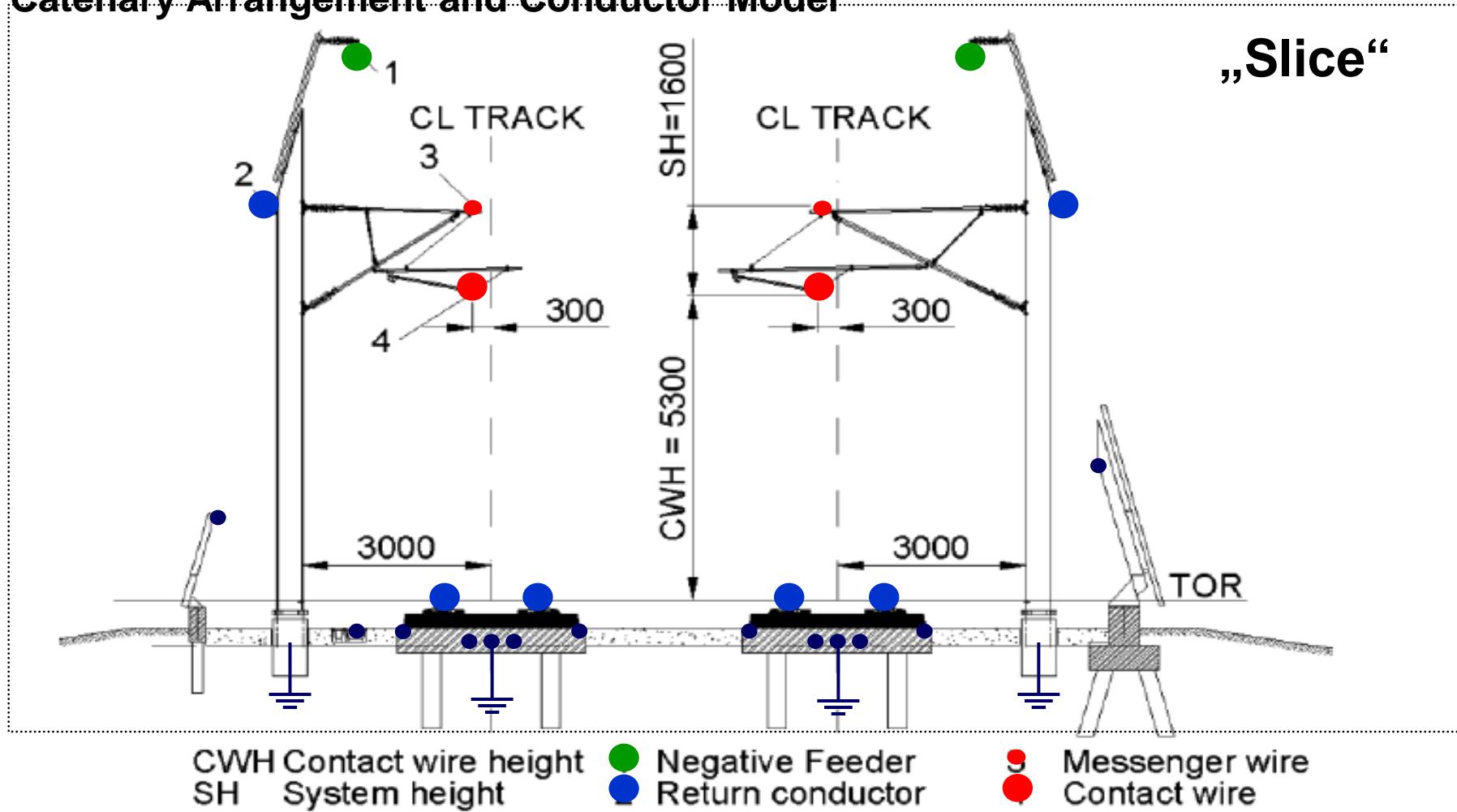
3 AC 110 / 220 kV

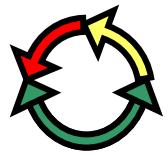




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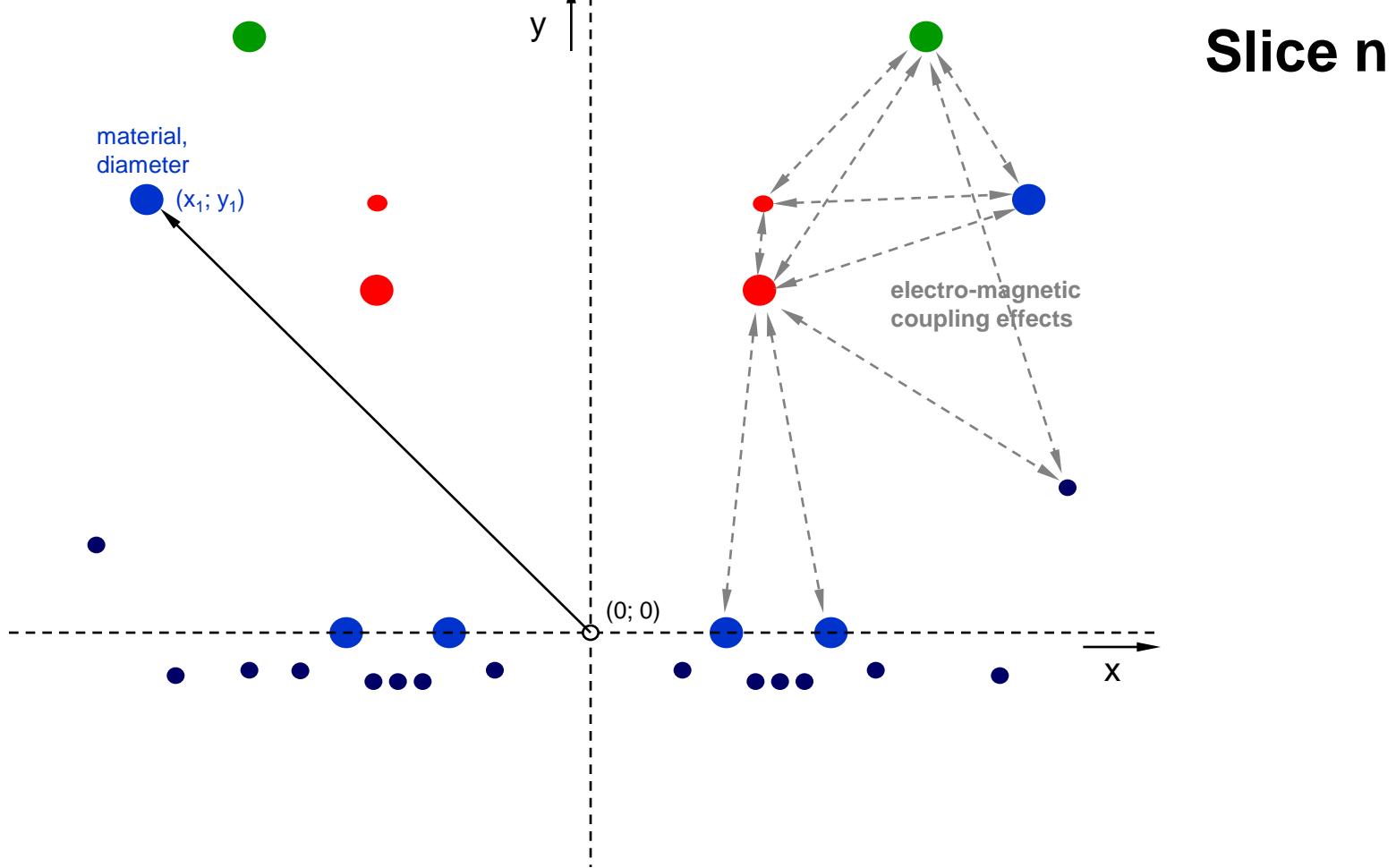
Catenary Arrangement and Conductor Model

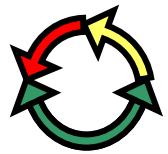




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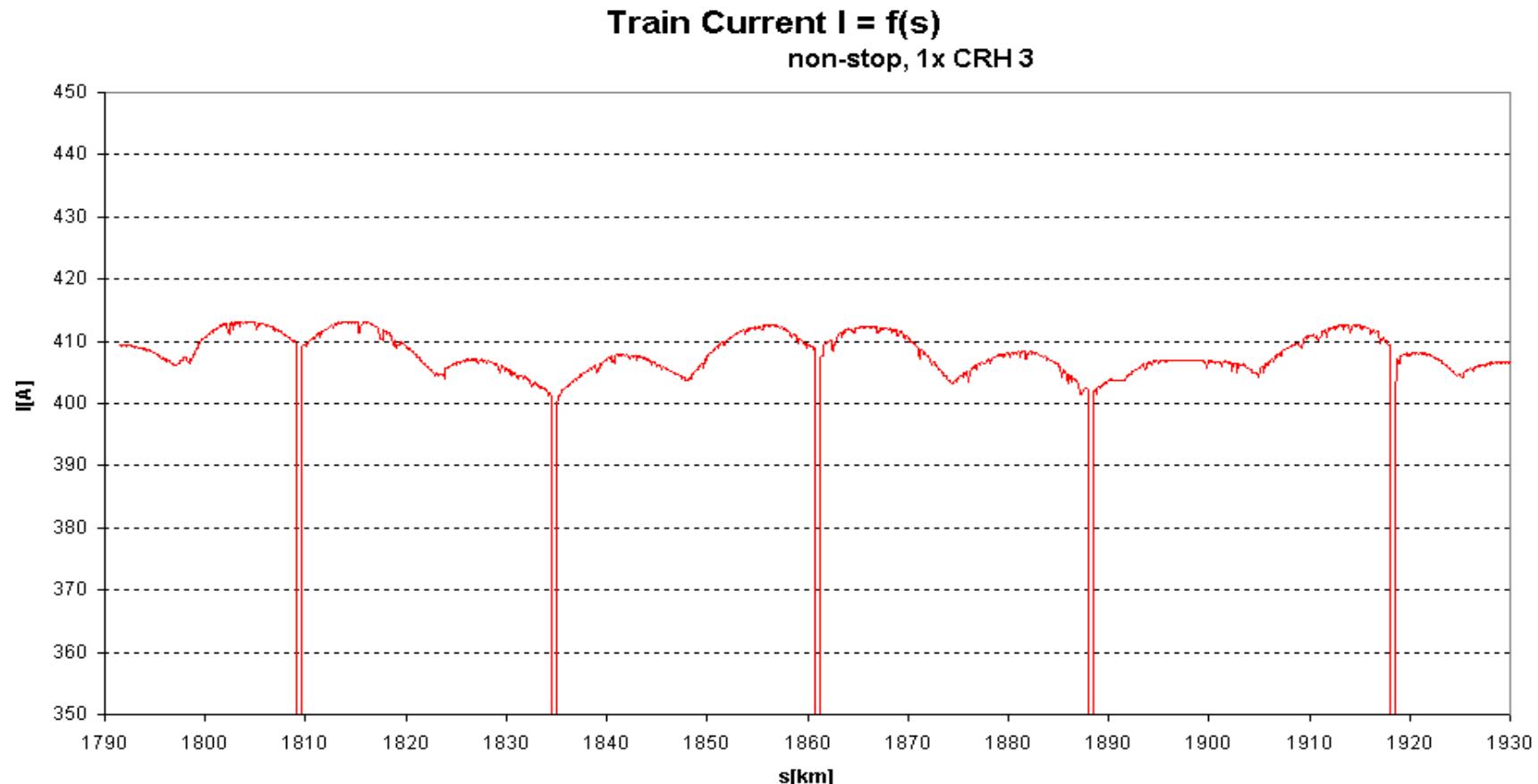
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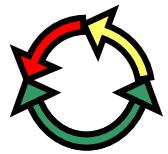




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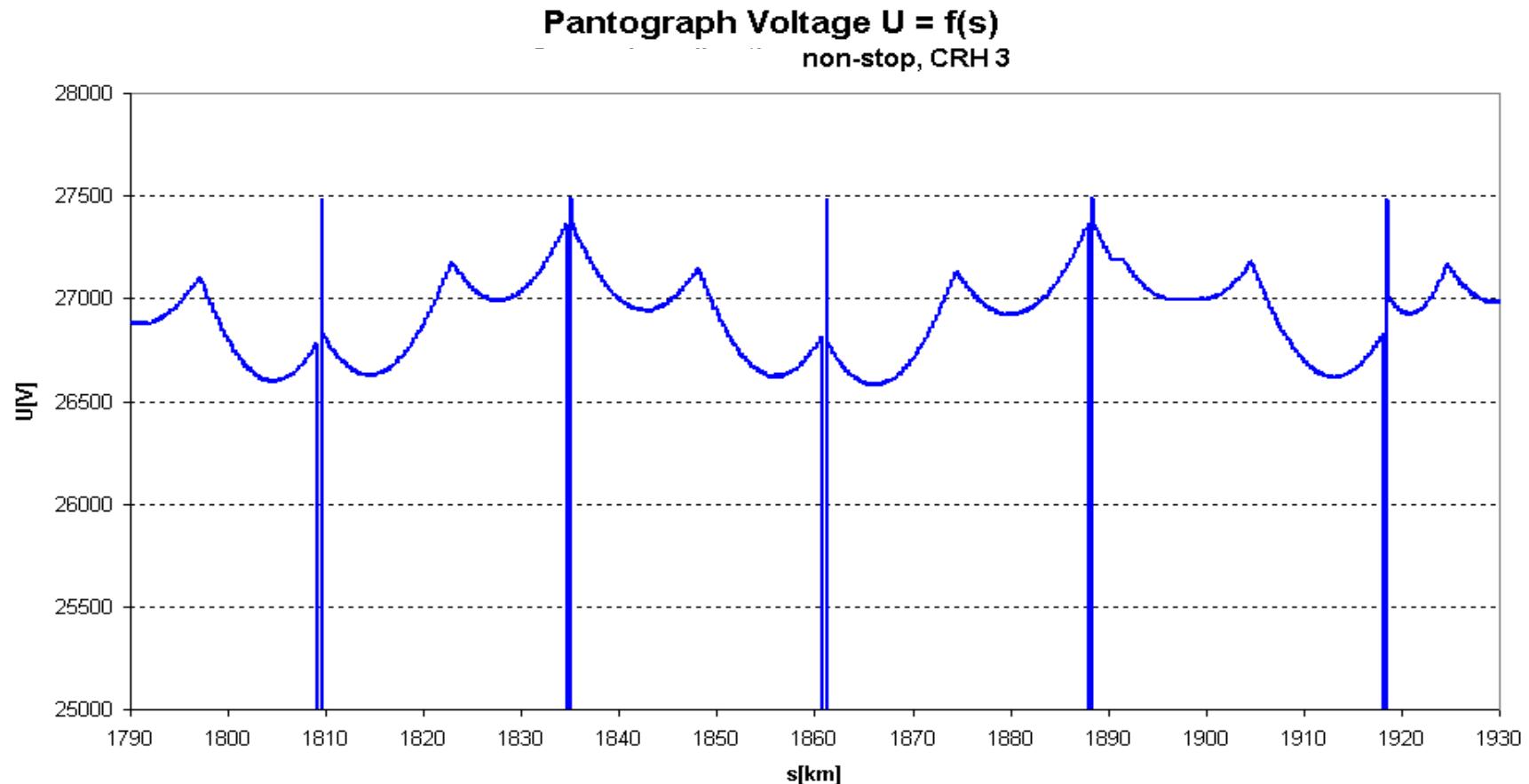
单列车模拟 Single Train Simulation





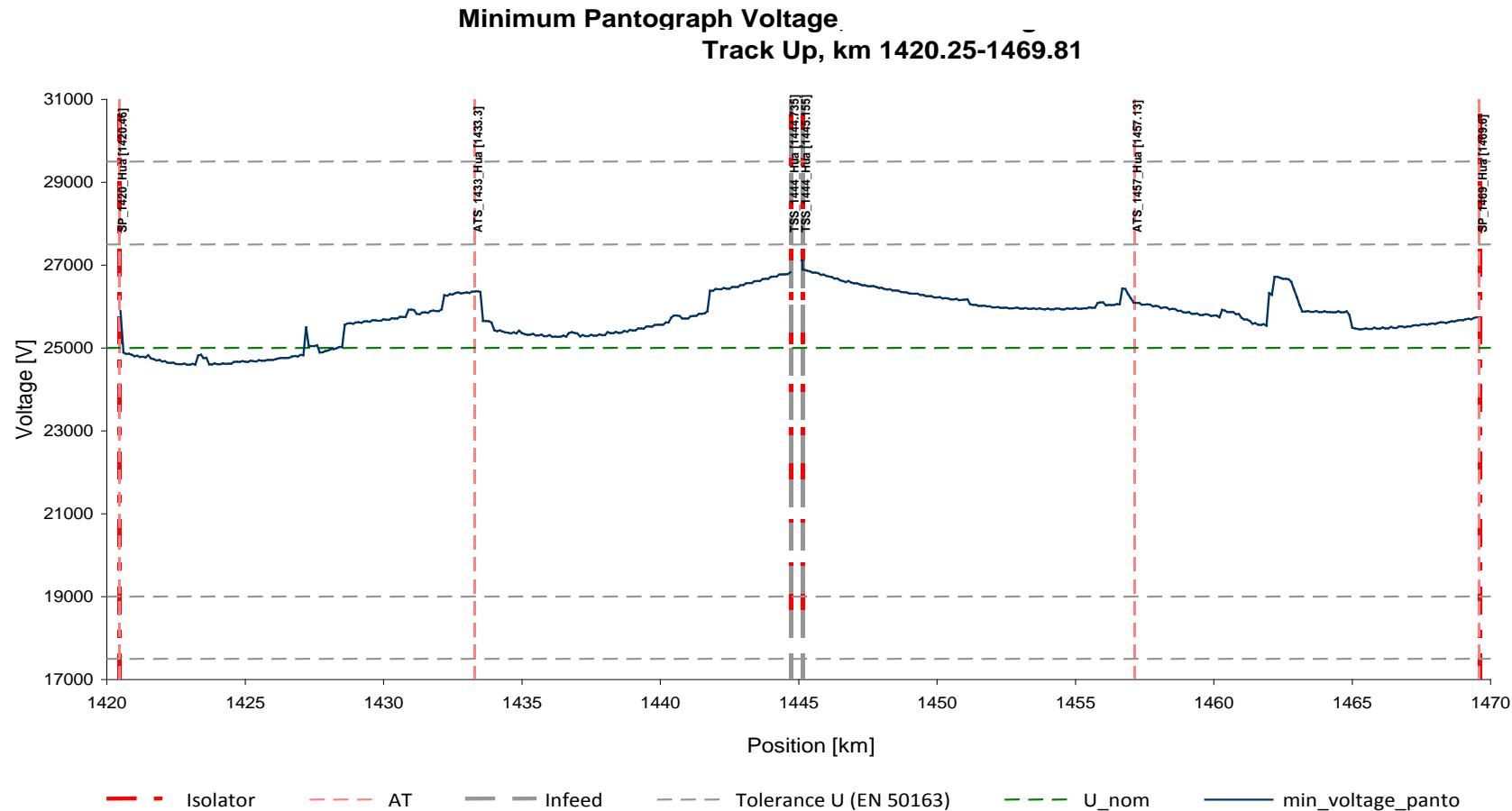
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单列车模拟 Single Train Simulation



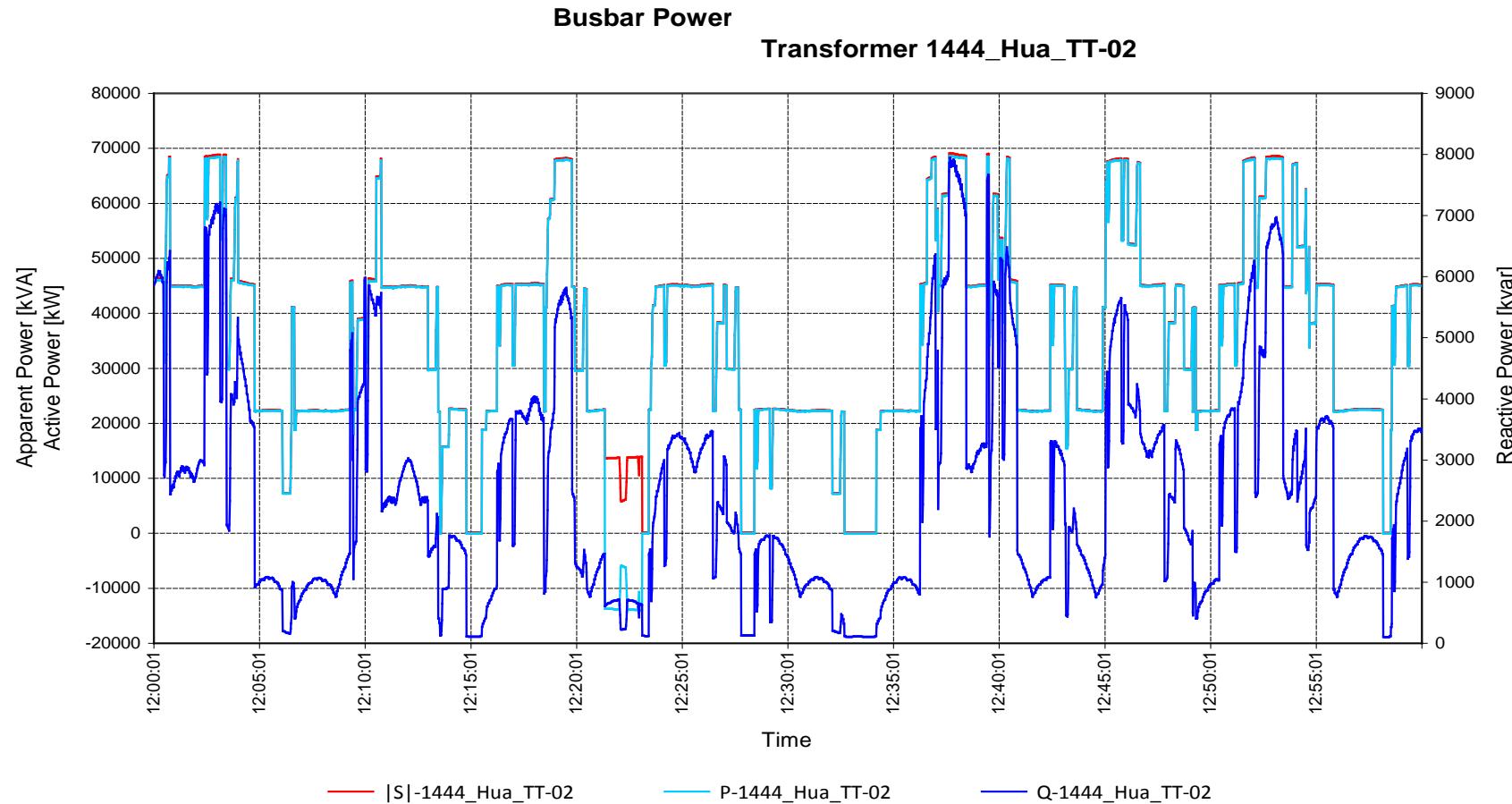


模拟结果：接触网 Simulation Results: OCS





模拟结果： TSS Simulation Results: TSS

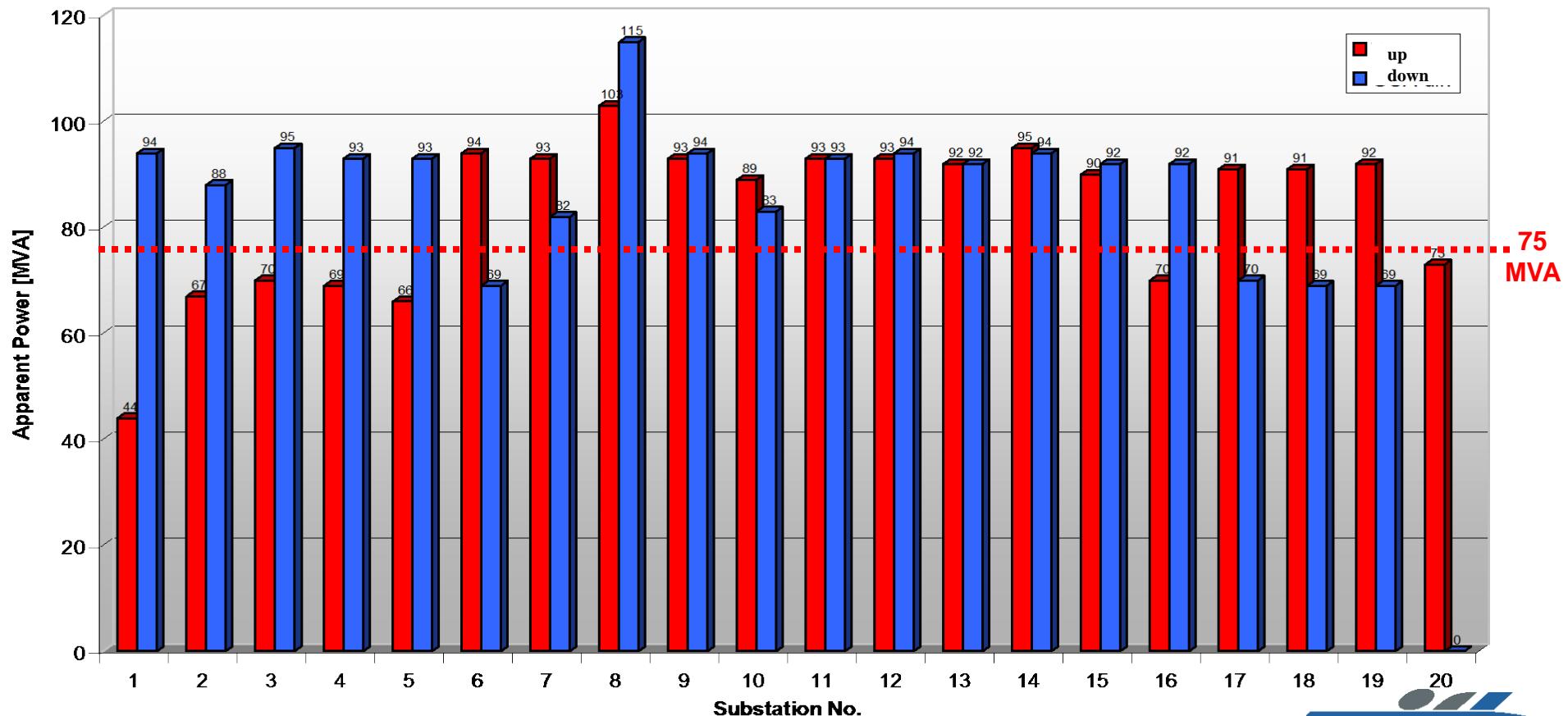




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TSS 变压器功率 TSS Transformer Power

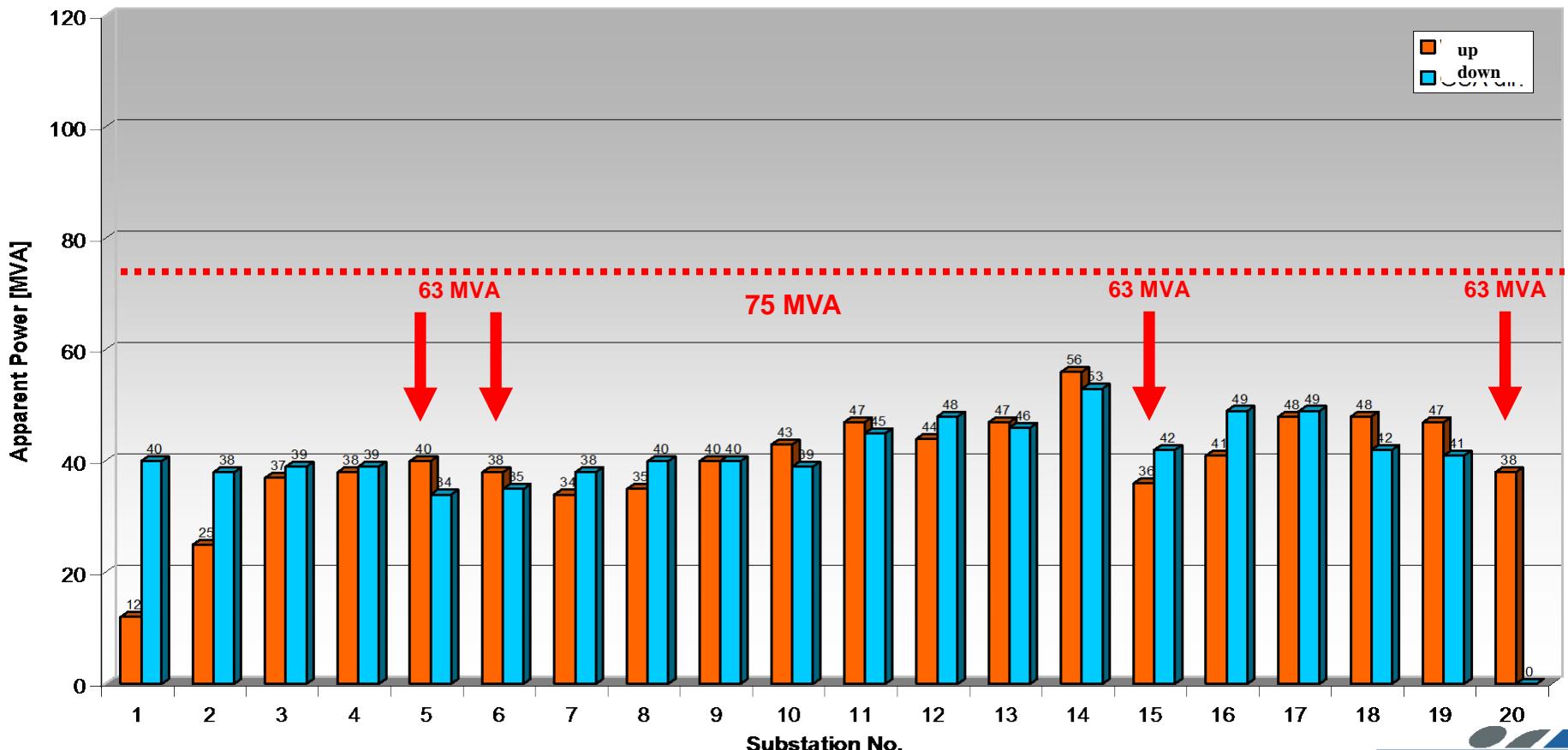
Maximum Substation Power





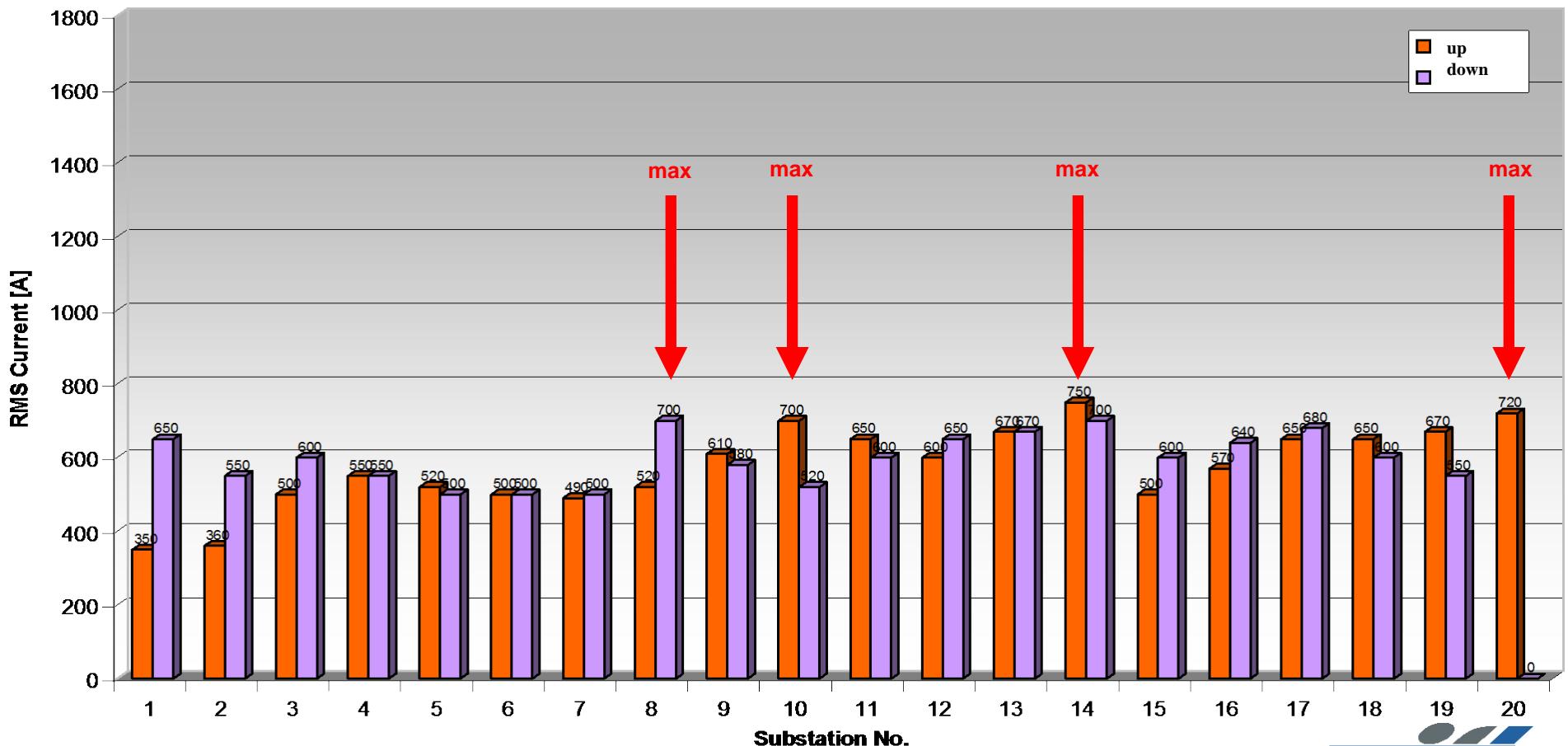
TSS 变压器功率 TSS Transformer Power

Average Substation Power (1h)



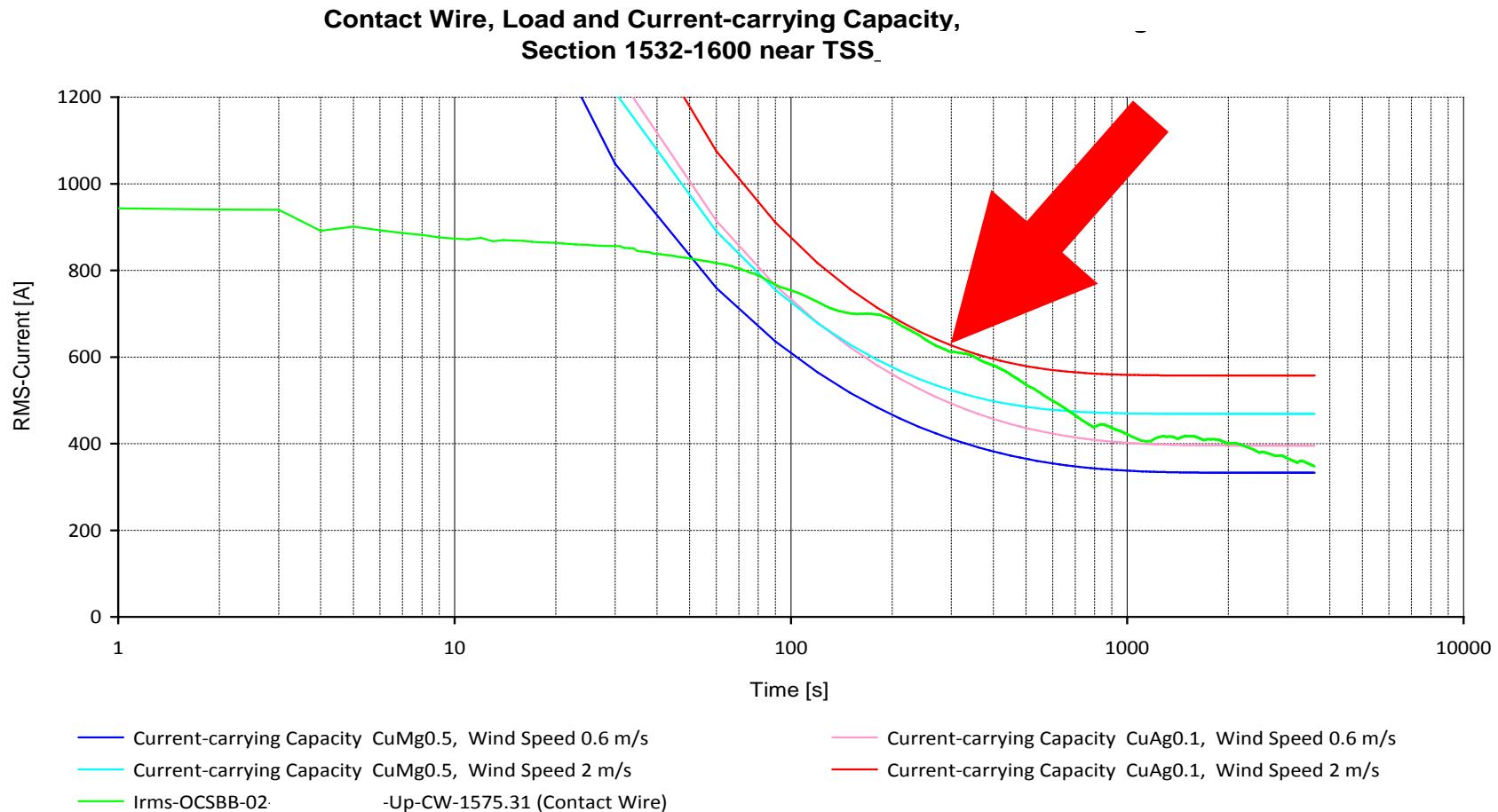


馈线电流 Feeder Cable Currents OCS and Feeder Cable RMS Current (1h)



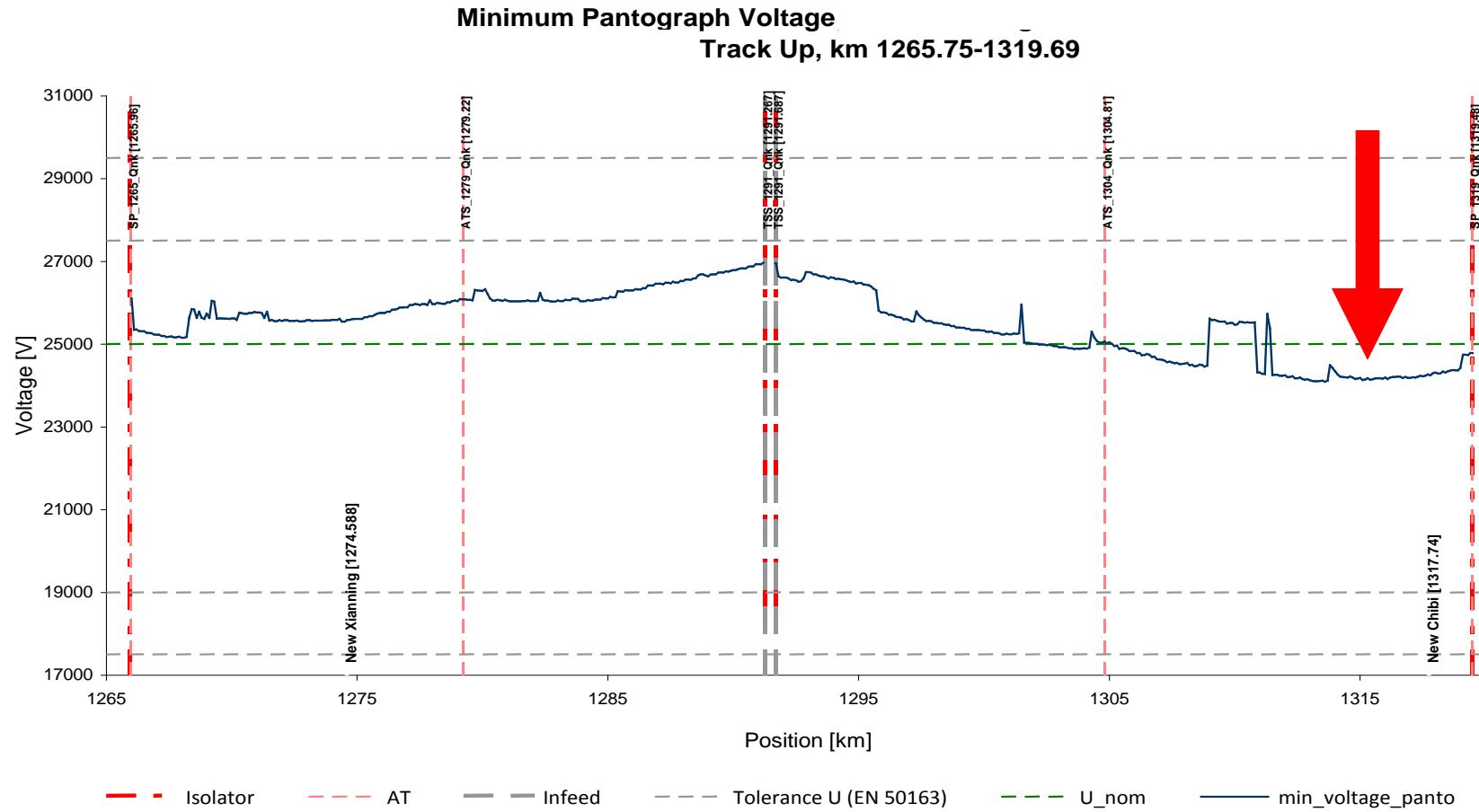


接触网RMS电流 (8) OCS RMS Current (8)



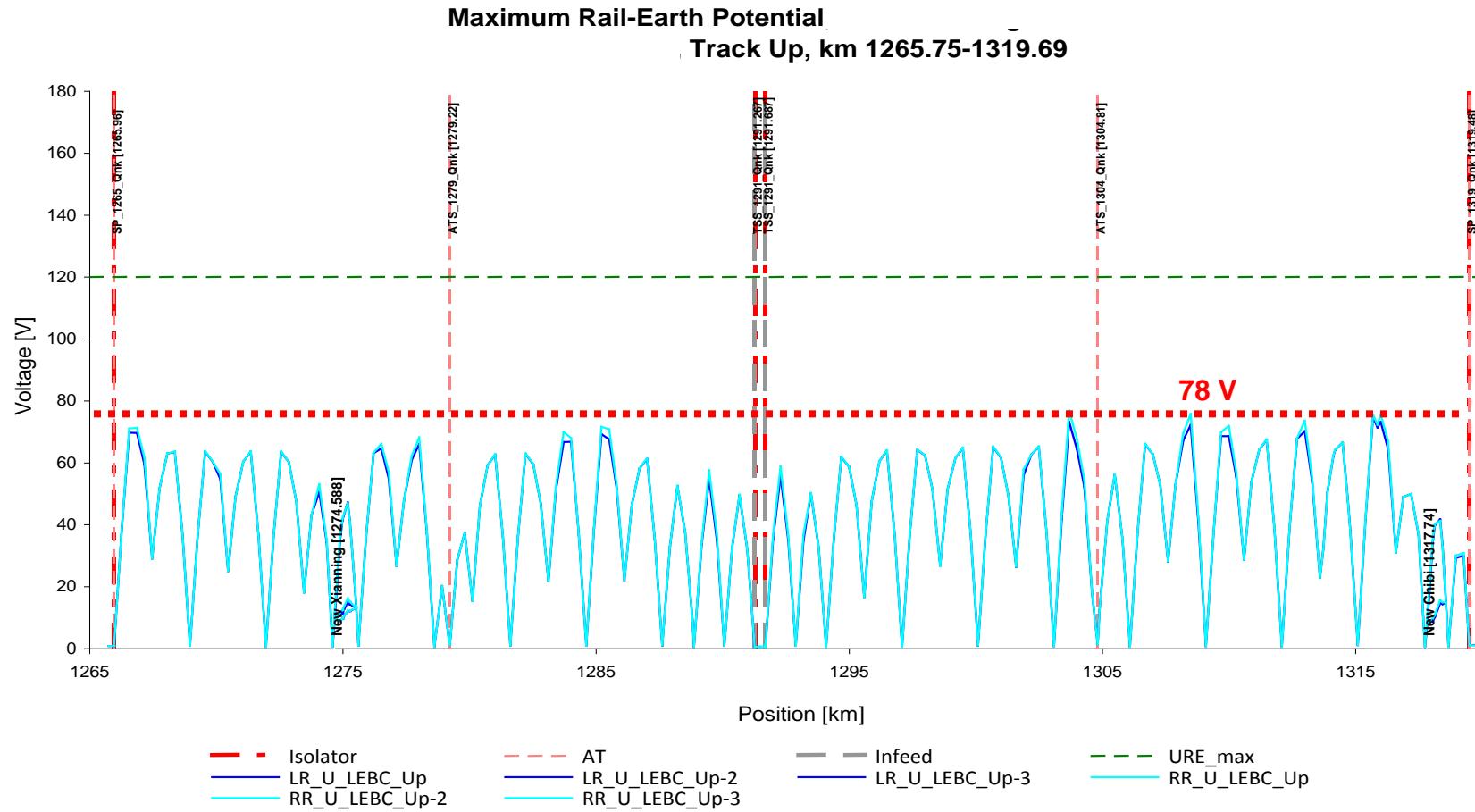


受电弓电压 (3) Pantograph Voltage (3)



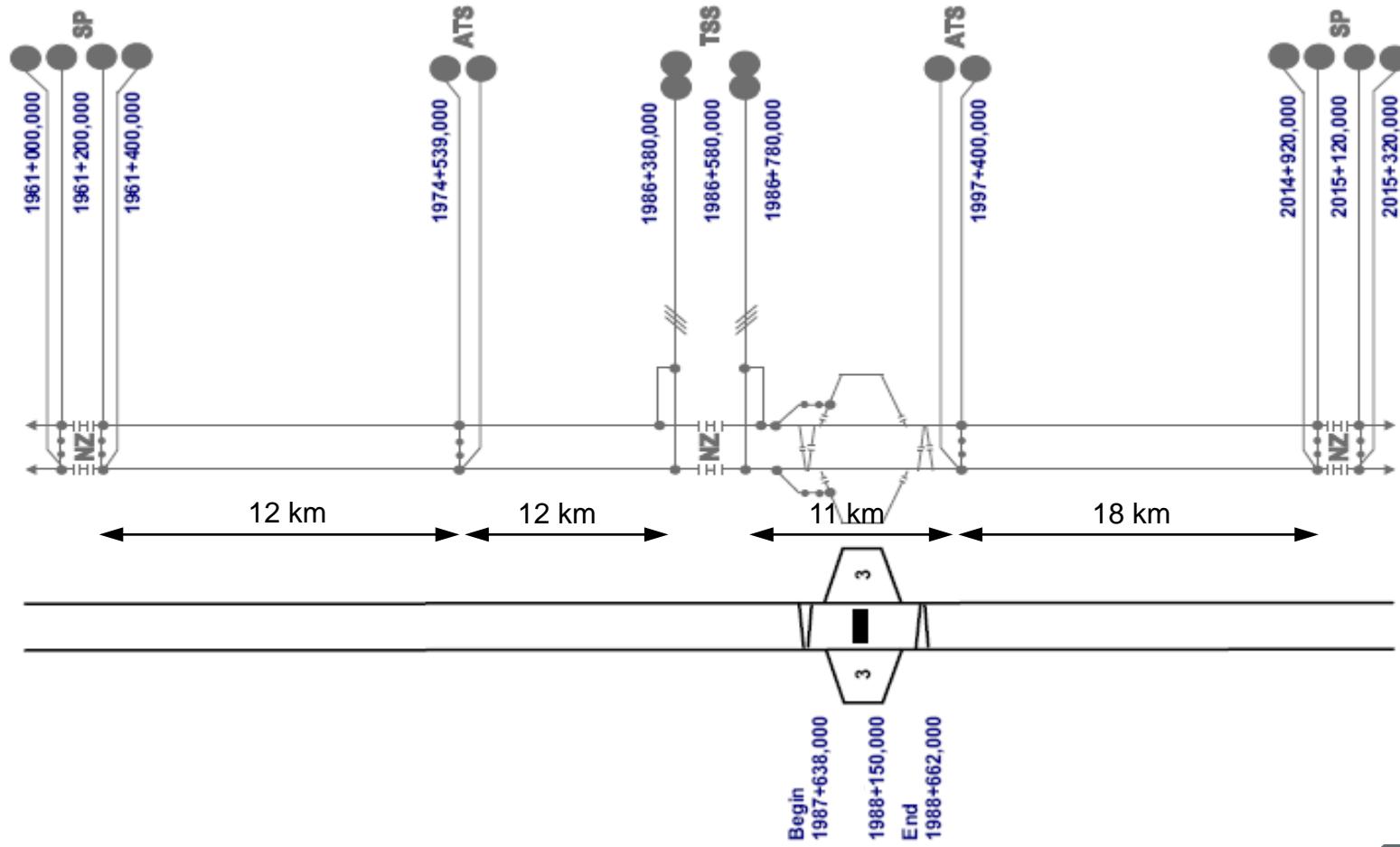


轨对地电压, 运行 (3-典型) Rail-to-Earth Voltage, Operation (3 – typical)



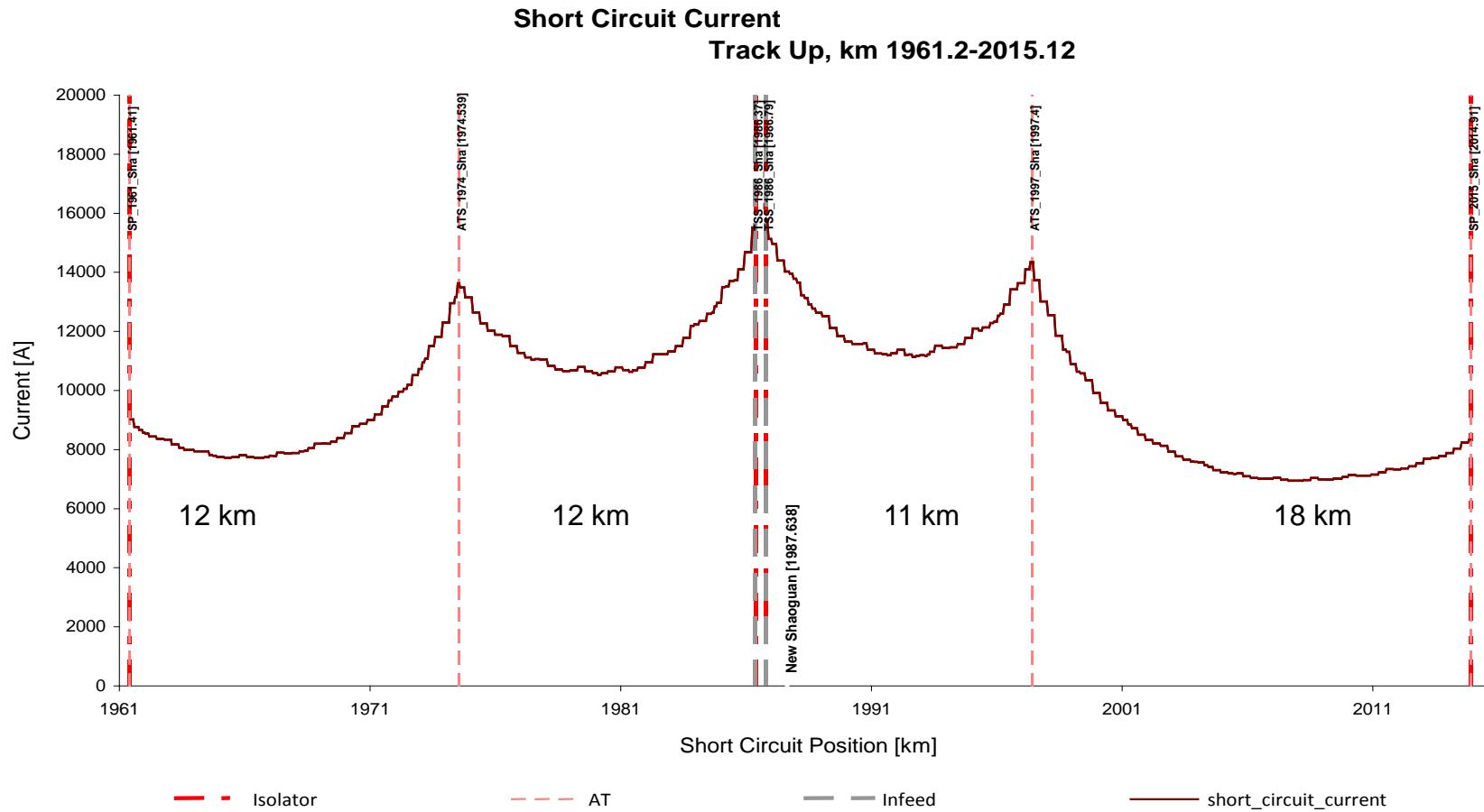


接触网馈电图, 16供电段 OCL Infeed Schema, Section 16



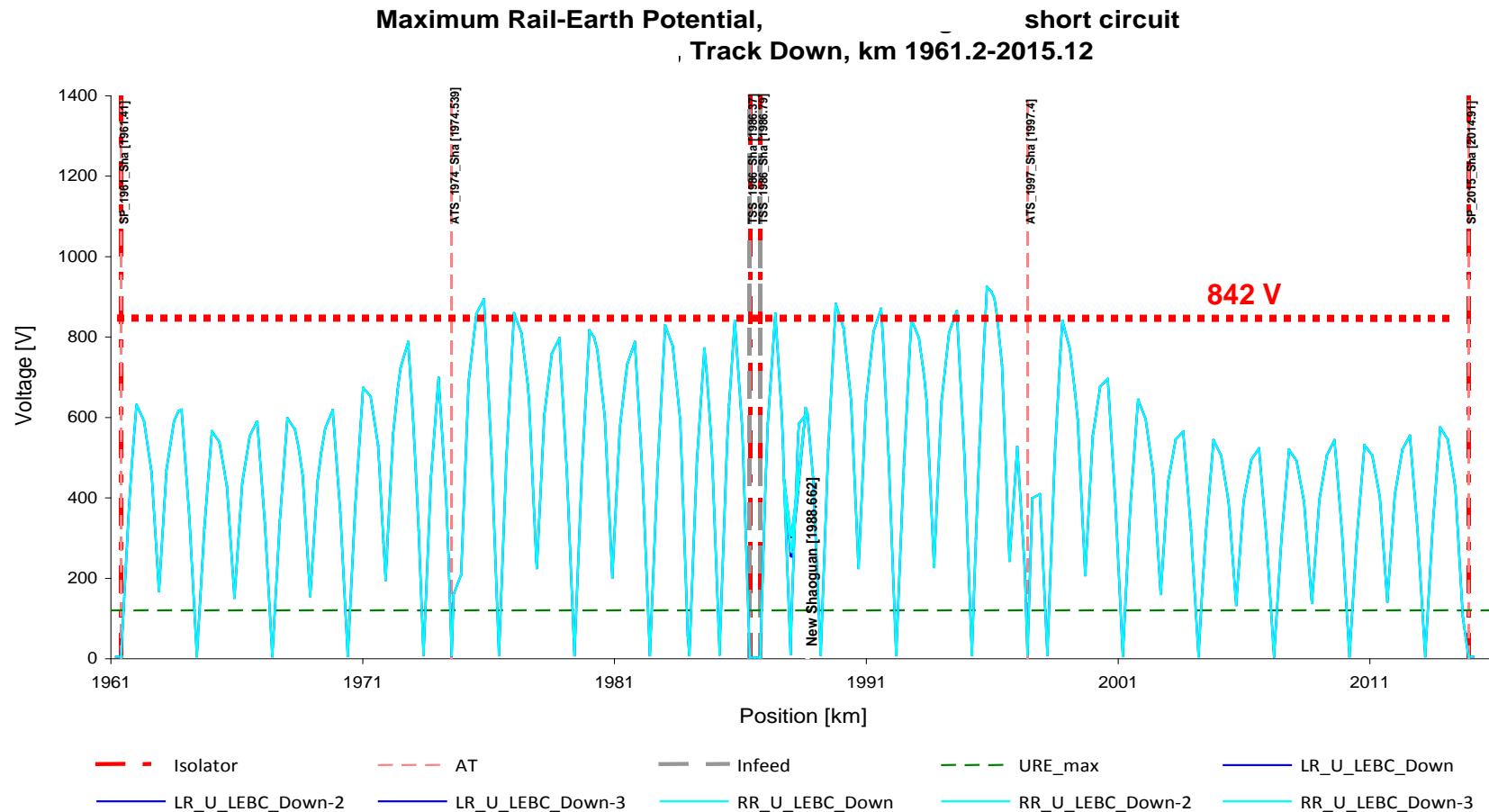


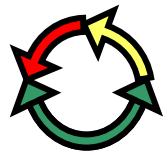
短路（16 – 典型） Short Circuit (16 – typical)





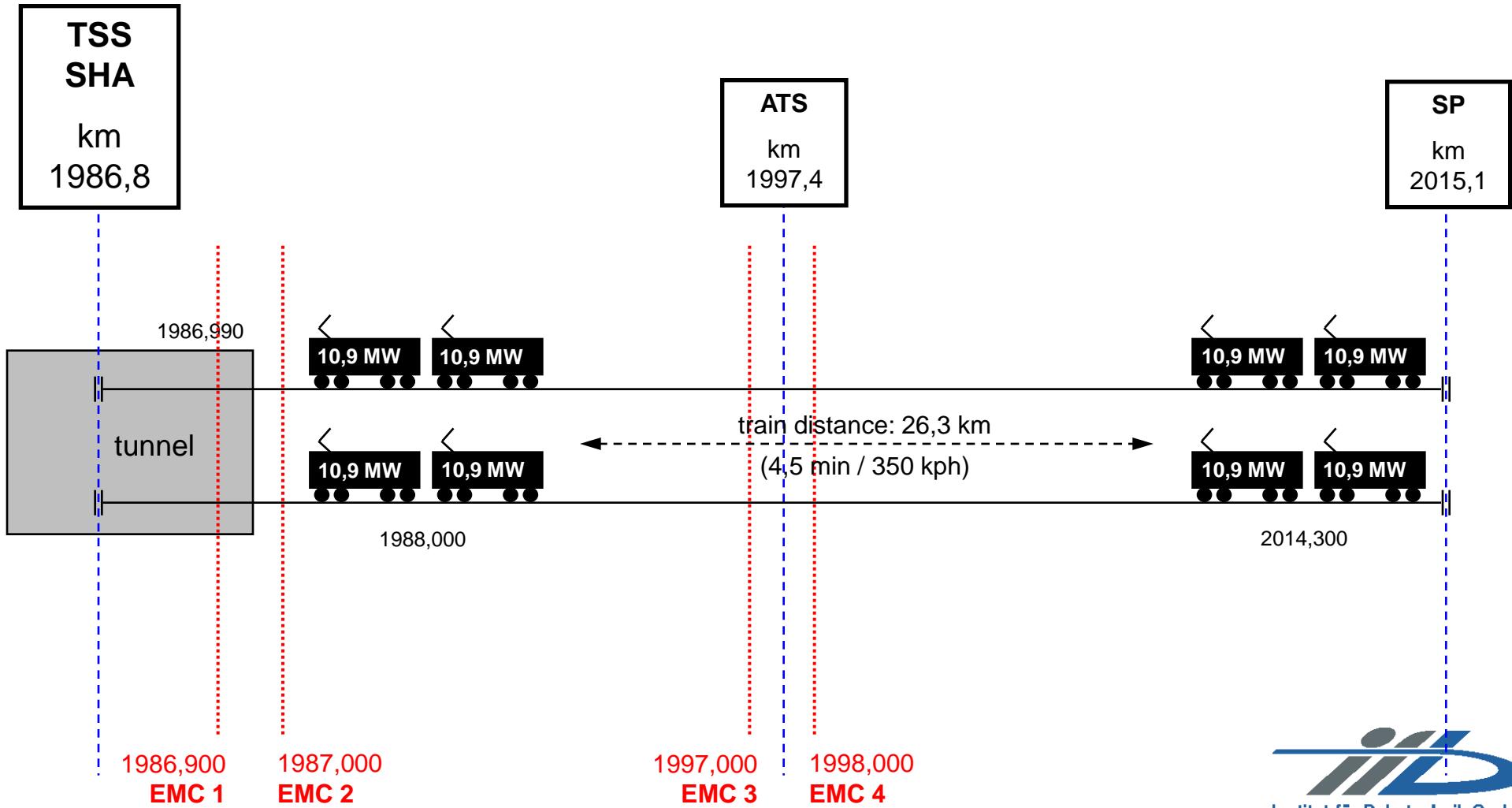
轨对地电压, 短路(16 – 典型) Rail-to-Earth Voltage, Short Circuit (16 – typical)





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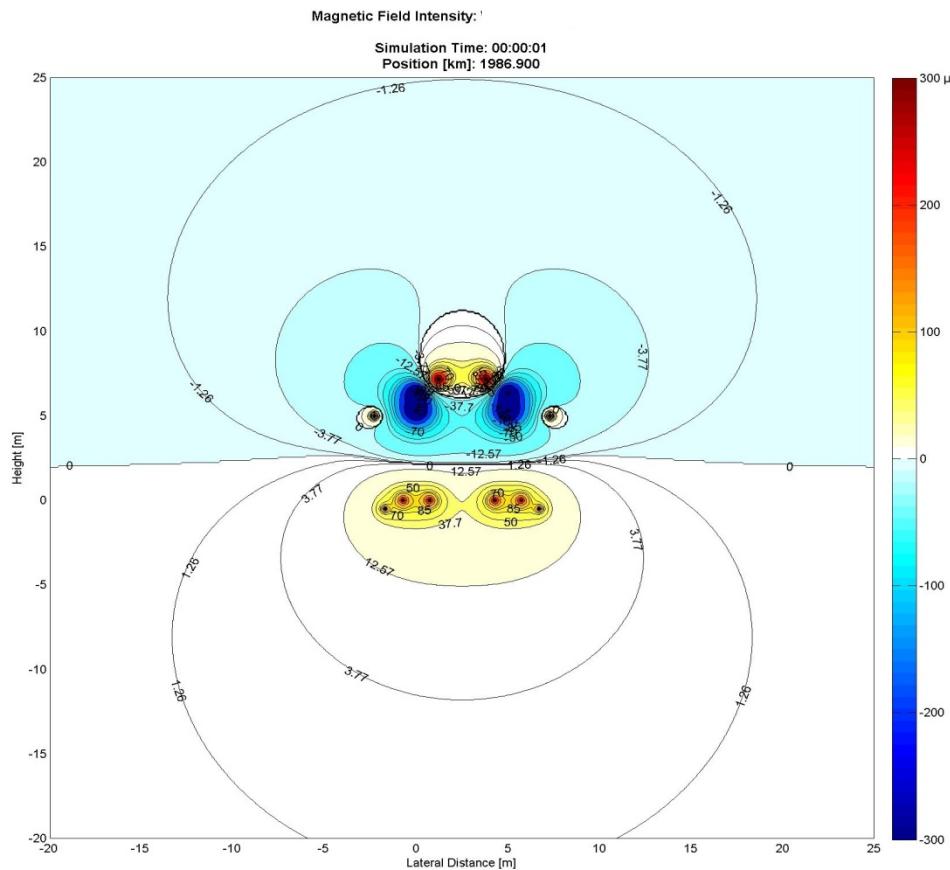
电流分配 (16 – 典型) Current Distribution (16 – typical)



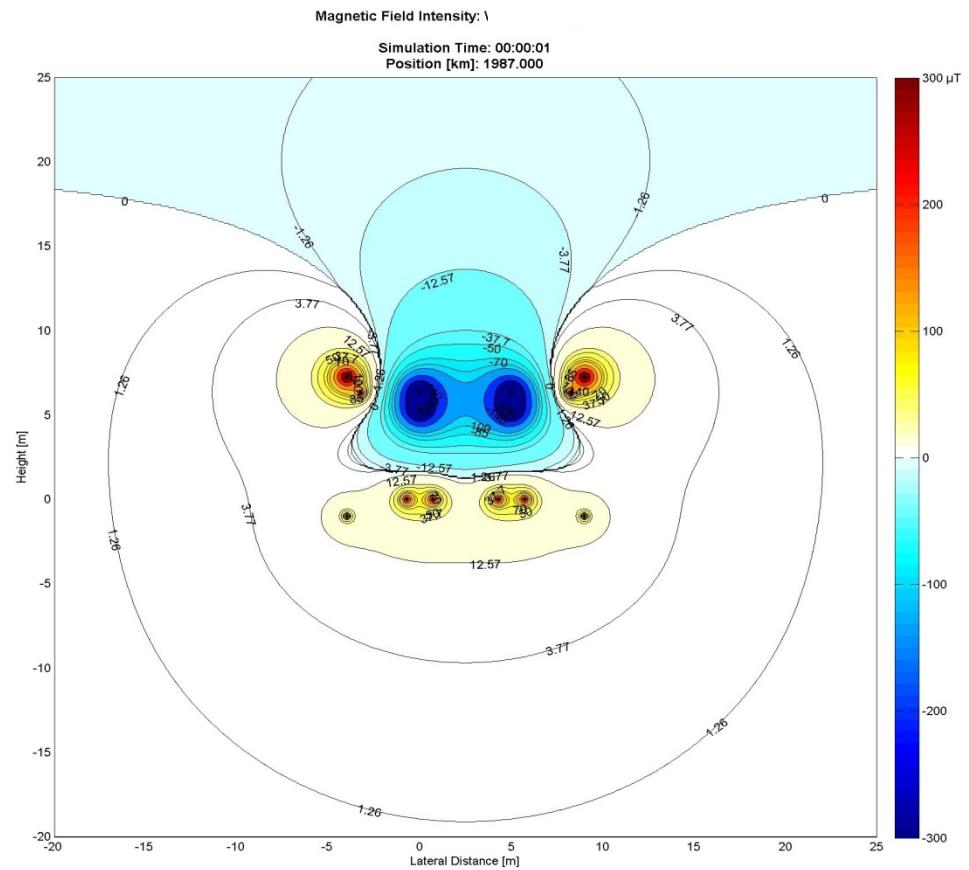


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电磁磁场50 Hz(16 – 典型) Electromagnetic Fields 50 Hz (16 – typical)



隧道 tunnel

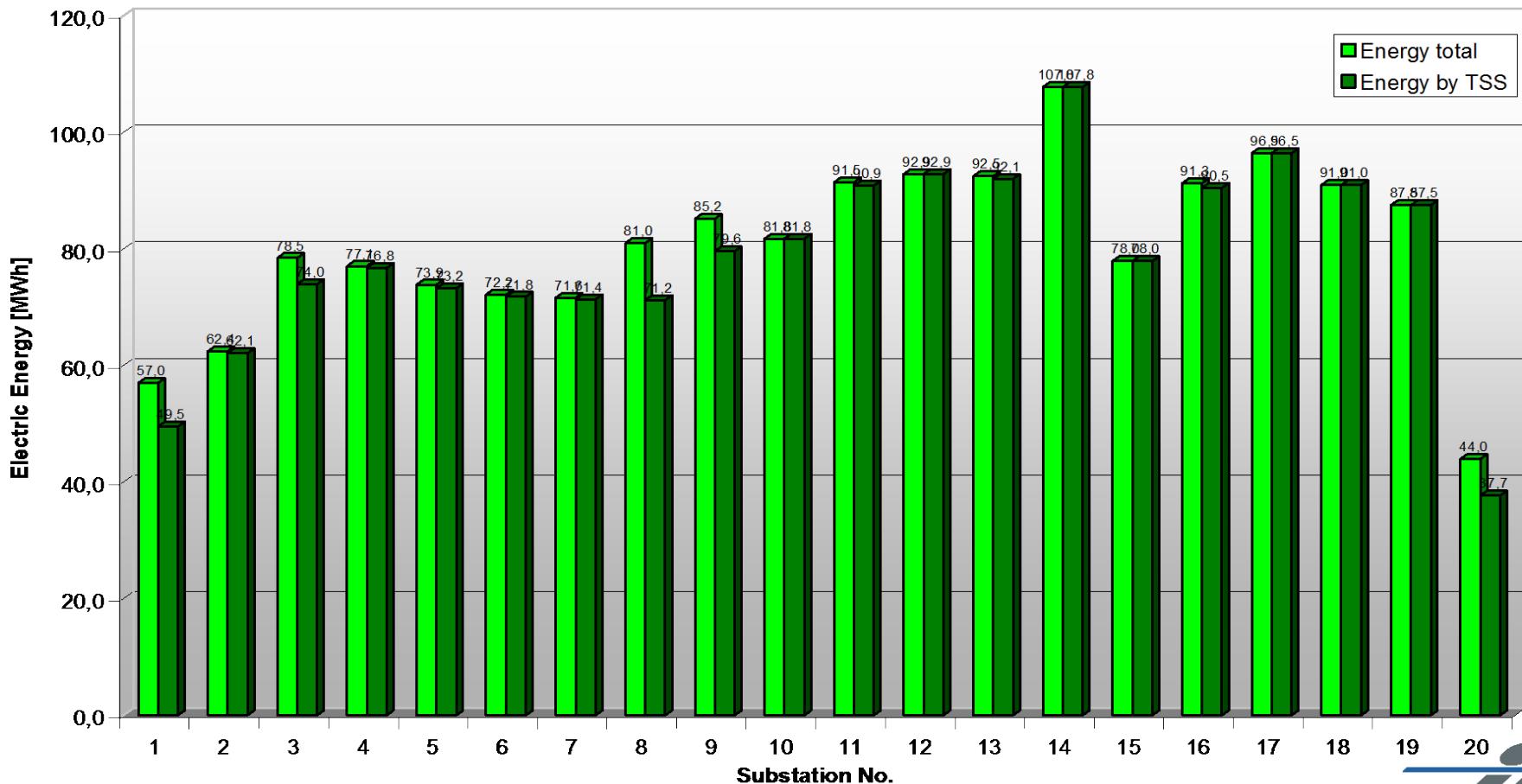


路基 subgrade



能源消耗 Energy Consumption

TSS Energy Delivery (1 h)





供电网络能源平衡和损失(8) Network Energy Balance and Losses (8)

Energy Consumption And Losses Overview

Cha 1532-1600

Energy output to catenary at substation [kWh]	72300,187
Energy input from catenary at substation [kWh]	1154,082
Total energy at substation [kWh]	71146,105
Vehicles energy consumption [kWh]	78540,848
Vehicles braking energy used for auxiliaries [kWh]	639,139
Vehicles braking energy recovered by catenary [kWh]	9230,867
Total used vehicles braking energy [kWh]	9870,007
Total vehicles energy [kWh]	69309,980
Total energy consumption [kWh]	81016,112
Energy consumption from national power grid [kWh]	71233,480
Average efficiency of traction power supply	97,6%

Losses in contact wire [kWh]	525,588
Losses in messenger wire [kWh]	565,248
Losses in negative feeder [kWh]	481,426
Losses in return conductor [kWh]	138,879
Losses in left rail [kWh]	13,174
Losses in right rail [kWh]	13,196
Losses in LEBC [kWh]	31,117
Total losses in conductors [kWh]	1768,629
Losses in connectors [kWh]	1,495
Losses in autotransformers [kWh]	21,896
Total losses in catenary system [kWh]	1792,020
Losses in feeders [kWh]	44,072
Losses in traction transformers [kWh]	87,375



评估标准 Evaluation Criteria

- 与电网的连接条件（电力需求、不平衡）**Connection conditions to the power grid** (power demand, unbalance)
- 变电所和馈电段的额定分配 **Rational distribution of substations and feeding sections**
- 足够的变压器额定（TSS, ATS, SP）**Sufficient transformer rating** (TSS, ATS, SP)
- 接触线电压等级（符合一般标准）**Overhead line voltage level** (fulfilment of common standards)
- 选择足够的电线和电缆的横截面（电流载荷）**Sufficient choosing of wire and cable cross sections** (current load)
- 供电系统对列车驾驶动力学的影响 **Influences of the power supply system on train driving dynamics**
- 短路条件（电流等级、）**Short circuit conditions** (current level, longitudinal distribution)
- 接触电压等级（在运营和短路期间）**Touch voltage level** (during operation and short circuit)
- 沿铁路线的电磁磁场（50 Hz）**Electromagnetic field level along the railway line** (50 Hz)
- 能耗和损失平衡（列车和馈电段）**Energy consumption and losses balance** (train and feeder section level)



谢谢！

Thank you!