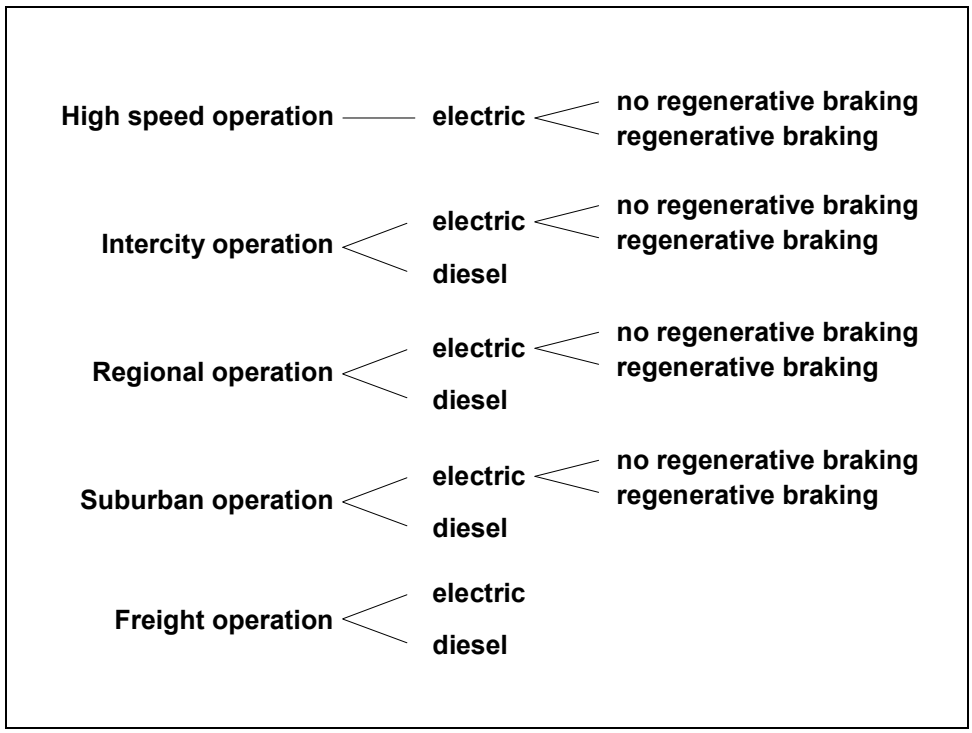
**The concept of elasticities**

The energy consumption of a train is influenced by a number of parameters such as mass, efficiency of traction equipment, running resistance and comfort functions. Most energy efficiency measures and technologies influence one or several of these parameters. The concept of elasticities helps to calculate the corresponding effect on the total energy consumption of the train. For example, an elasticity of energy consumption with respect to running resistance of 0,4 means that reducing running resistance by 10%, cuts energy consumption by $0{,}4 \times 10\ \% = 4\ \%$.

Obviously these elasticities heavily depend on the individual train and operation context. However, a number of typical operation contexts can be given which yield good estimates for a wide range of real train runs. Within in the EVENT project the following 13 train/operation types were chosen as representative:




For these 13 types the elasticities of total energy consumption with respect to mass, running resistance and efficiency of the power train were calculated. The results are given in the following table:

| | Traction | Recuperation | Elasticities with regard to | | |
|---|---|---|---|---|---|
| | | | traction efficiency | mass | running resistance |
| **High speed train** | **electric** | **no** | 1,00 | 0,17 | 0,63 |
| | | **yes** | 1,11 | 0,12 | 0,66 |
| **Intercity train** | **electric** | **no** | 1,00 | 0,19 | 0,61 |
| | | **yes** | 1,12 | 0,14 | 0,65 |
| | **diesel** | **-** | 1,00 | 0,19 | 0,61 |
| **Regional train** | **electric** | **no** | 1,00 | 0,52 | 0,27 |
| | | **yes** | 1,33 | 0,44 | 0,31 |
| | **diesel** | **-** | 1,00 | 0,52 | 0,27 |
| **Suburban train** | **electric** | **no** | 1,00 | 0,64 | 0,15 |
| | | **yes** | 1,42 | 0,57 | 0,18 |
| | **diesel** | **-** | 1,00 | 0,64 | 0,15 |
| **Freight** | **electric** | **no** | 1,00 | 0,29 | 0,71 |
| | **diesel** | **-** | 1,00 | 0,29 | 0,71 |

Example: *Medium frequency transformer*
Efficiency of medium frequency transformers: > 94%
Efficiency of conventional transformers: ~ 92%
This corresponds to an increase of efficiency of the transformer of 2 – 3%. This efficiency gain directly translates into an equal gain in the overall efficiency of the power train (since it is the product of the efficiencies of the individual components). This yields the following table specifying in the last column the effect on the total energy consumption for the individual train classes.

| | Traction | Brake energy recovery | Effect on efficiency of power train | Elasticity with regard to efficiency of power train | **Effect on total energy consumption** |
|---|---|---|---|---|---|
| High speed train | Electric (16,7 Hz) | no | 2 – 3 % | 1,00 | **2 – 3 %** |
| | | yes | | 1,14 | **2 – 3 %** |
| Intercity train | Electric (16,7 Hz) | no | | 1,00 | **2 – 3 %** |
| | | yes | | 1,15 | **2 – 3 %** |
| Regional train | Electric (16,7 Hz) | no | | 1,00 | **2 – 3 %** |
| | | yes | | 1,43 | **3 – 4 %** |
| Suburban train | Electric (16,7 Hz) | no | | 1,00 | **2 – 3 %** |
| | | yes | | 1,55 | **3 – 5 %** |
| Freight | Electric (16,7 Hz) | no | | 1,00 | **2 – 3 %** |
| | | | | **Range:** | **2 – 5 %** |