Energy savings thanks to traffic flow management

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The good old times

If you have one train in a network...:

- it needs energy for the journey from A to B
- there are no other trains which disturb your run
- it is up to you how much energy you use

Luzern in 2009 (Photo from Internet)
If you have a network with many trains...:

- it still needs energy from A to B
- other trains may disturb your run as soon as there are delays
- energy consumption is partly out of your control!
Level 1: **Energy efficient driving style**

... by training of the train drivers:
Level 2: **Advisory systems**

... on single trains, based on timetable:

![Graphs showing speed and energy savings](image-url)

*Energy savings*
Level 3: *Advisory systems*

... with on-line infrastructure information:

![Stop at signal vs No Stop](image)

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Energy savings

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But *in reality*

- Complex networks
- mixed traffic
Level 4: *Network optimisation*

Which is the routing of trains for:
- lowest total *time delay*
- lowest total *energy consumption*

A fast analysis of a large number of combinations is necessary and requires efficient numerical methods.
System study

The following results are from a system study, performed in 2008 / 2009 by *emkamatik* on behalf of SBB, with the financial support of the Swiss Federal Office of Energy (BFE), and partly based on earlier studies done by SBB.

Main characteristics:

- Focus on **high network capacity at lowest energy consumption**
- Reduced network dimensions (for development)
- Real train data
- Demonstration software based on MATLAB
- Core is a **very fast train run simulation** for speed and energy consumption versus location / time
The fast algorithm allows the calculation of all reasonable routings in a few seconds:
Since both time delay (caused by conflicts between trains) and energy consumption are calculated simultaneously, it is possible to define a target function for selection of the route:

\[ \sum k_i \Delta t_i + \sum E_i = \text{minimal} \]

By means of individual factors \( k_i \) per train, it is even possible to define priorities:

- passenger versus freight trains
- connections between trains
- etc.
Network simulation results

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Required system architecture

- Network data
- Preprocessing
- Timetable

- Train data
  - Signal box
  - Route request
    - Network calculation (train run predictor)
      - Train positions
        - Loop repeated all 6 ... 15 seconds
      - Target times / deviation
  - Train

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The system study has shown:

- There are promising methods for on-line optimisation of rail traffic flow; energy consumption can be addressed explicitly.

- Energy consumption and network capacity are not in contradiction.

- A reduction of the total consumption by about 5% seems to be realistic in the medium future in Switzerland.