# Influence of Tribology on Global Energy Consumption, Costs and Emissions

**Our intention with this article is to assess the influence of friction and wear in energy consumption, economic losses and $CO_2$ emissions worldwide, in the four main energy consuming sectors: transportation, industry, energy industry, and residential. Potential savings that are then estimated can be gained by putting into use new tribological solutions that have come about during the last decade or so.**

## Methodology

The global calculations used in this paper were carried out according to a methodology that was developed for the calculation of the impact of friction on passenger cars and in an industrial case study. The same methodology was later extended to include the impact of friction and wear in mining.

The methodology is based on a combination of the analyses of several physical phenomena resulting in the consumption of energy in mechanical equipment. It includes the following analyses and calculations:

1. An estimation of the global energy consumption in targeted economic sectors.

2. Calculation of friction, wear and energy losses in components and machinery used in such sectors.

3. Estimation of their operational effects.

4. Estimation of tribocontact-related friction and wear losses today and in the future.

5. Calculation of global energy consumption today due to friction and wear and potential savings in the short and long runs.

The methodology was first used for passenger cars. A first step was estimating annual fuel consumption according to reliable statistics divided by the number of cars worldwide which gives the energy used in one global average car. Based on statistics, a technical specification for a global average passenger car as well as global average operational conditions were defined.

The components of this global average passenger car were then considered and the friction aspect was estimated and further broken down into microscale lubrication and contact mechanisms.

The level of typical coefficients of friction in the global average car components was defined based on data from published literature. Similar levels of coefficients of friction for new cars, the lowest levels measured in laboratories so far, and estimated levels until 2025 were estimated. This data was upscaled to a global level and the global energy consumption due to friction as well as potential fuel, cost and $CO_2$ savings were then calculated.

## Potential savings by tribological advances

There have been huge strides in finding new tribological solutions to reduce friction and wear over the last decades. This development is illustrated in Figure 1 where the typical friction coefficients in tribological contacts in trucks and buses on average, in today's new commercial vehicle is shown together with values predicted for future vehicles in the year 2025, according to contact and lubrication mechanisms.

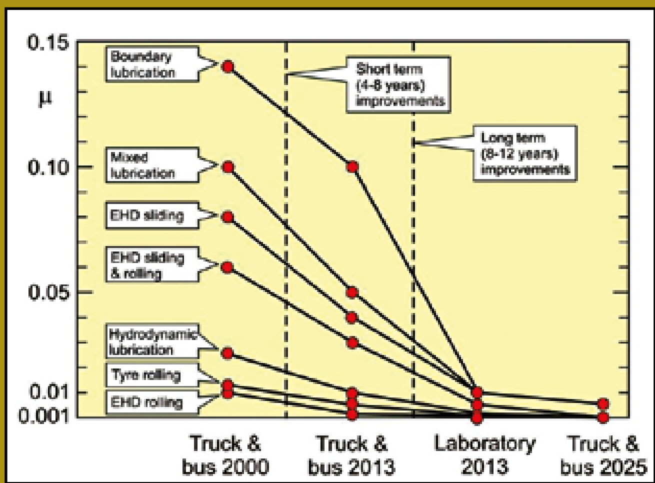


Figure 1 Trends in the reduction of the coefficient of friction in trucks and buses for different lubrication mechanisms and for rolling friction

The mechanical devices used in the four economic sectors, the level of new technological solutions implemented and operational conditions are considered. Based on that, the average friction and wear levels of today's devices are calculated and compared to the relative friction and wear reduction in today's new commercial devices, lowest levels measured in research laboratories today and levels estimated to be possible to achieve in future up to year 2030.

In the four case studies, the potential savings by implementing new tribological solutions were calculated both in the short term and long term, as shown in Figure 2.

The manufacturers of trucks and buses are more advanced and very quick in implementing new technologies and there as are big fleets with a limited number of owners, the implementation time is considered quite short. This is not the case in the mining industry with many owners who are sceptics or who harbour negative attitudes toward the deployment of new technologies.

The average implementation time in all sectors was in this study estimated to be eight years representing the short term and 15 years representing the long term based on considerations of the structure of the four sectors, average product lifetime and typical willingness to implement new technology in products.

The savings by implementing new friction and wear solutions were calculated both for the short term and long term.

The implementation of new technology largely worldwide would save in the short term 21.5 EJ energy, 455,000 million Euro and 1,460 $MtCO_2$ emissions. In the long run, the savings could easily amount to 46 EJ energy, 973,000 million Euro and 3,140 $MtCO_2$ emissions.

The savings would be 1.39 % of the GNP and 8.7% of the total global energy consumption for the time scale of 15 years.

and wear protection in vehicles, machinery and other equipment worldwide, energy losses due to friction and wear could potentially be reduced by 40% in the long term (15 years) and by 18% in the short term (8 years).

- On a global scale, these savings would amount to 1.4% of the GDP annually and 8.7% of the total energy consumption in the long term.
- The largest short term energy savings are envisioned in transportation (25%) and in power generation (20%) while the potential savings in the manufacturing and residential sectors are estimated to be ~10%. In the longer terms, the savings would be 55%, 40%, 25% and 20% respectively.

Fifty years ago, wear and wear-related failures were a major concern for UK industry and their mitigation was considered to be a major contributor to potential economic savings by as much as 95% in ten years through the development and deployment of new tribological solutions.

**Many owners who are sceptics or who harbour negative attitudes toward the deployment of new technologies**

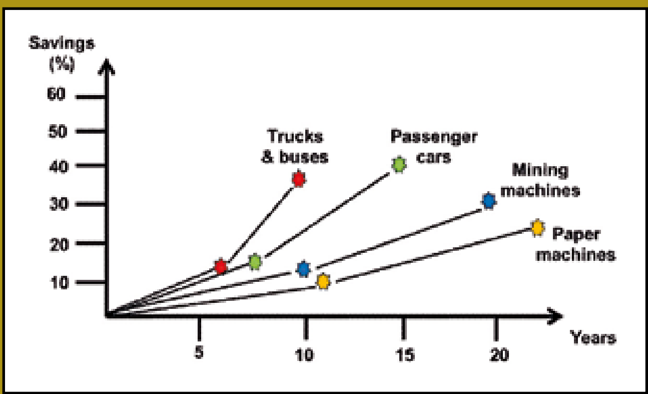


Figure 2 Calculated potential savings over current state of the art by the introduction of advanced tribology solutions in four case studies and their time scale of implementation

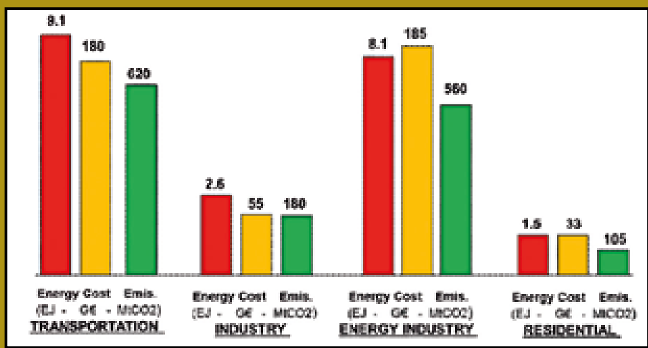


Figure 3 Potential annual energy, cost and $CO_2$ emission savings globally after 8 years of intensive advanced tribology implementation

The biggest potential savings that can be achieved in the timescale of eight years are in the transportation and energy industry sector, as shown in Figure 3. The implementation takes longer time in the industry and residential sectors so the short term savings are not that high.

## Conclusions

- In total, ~23% (119 EJ) of the world's total energy consumption originates from tribological contacts. Of that 20% (103 EJ) is used to overcome friction and 3% (16 EJ) is used to remanufacture worn parts and spare equipment due to wear and wear-related failures.
- By taking advantage of new surface, materials, and lubrication technologies for friction reduction

The corresponding estimated savings are still of the same order but the calculated contribution to cost reduction is about 74% by friction reduction and 26% from better wear protection.

Overall, wear appears to be more critical than friction as it may result in catastrophic failures and operational breakdowns that can adversely impact productivity and hence cost.

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