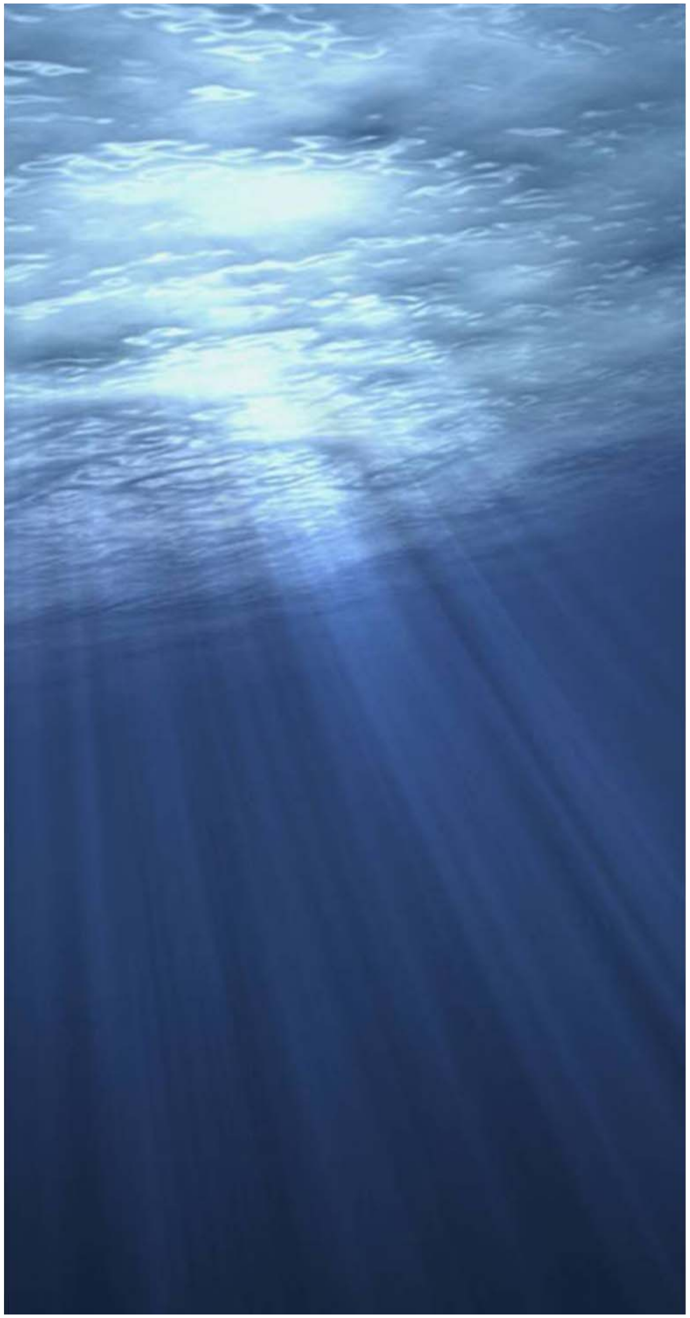

Assessing energy and environmental aspects of infrastructures

Systemanalys av transportinfrastrukturer och transporter: Botniabanan

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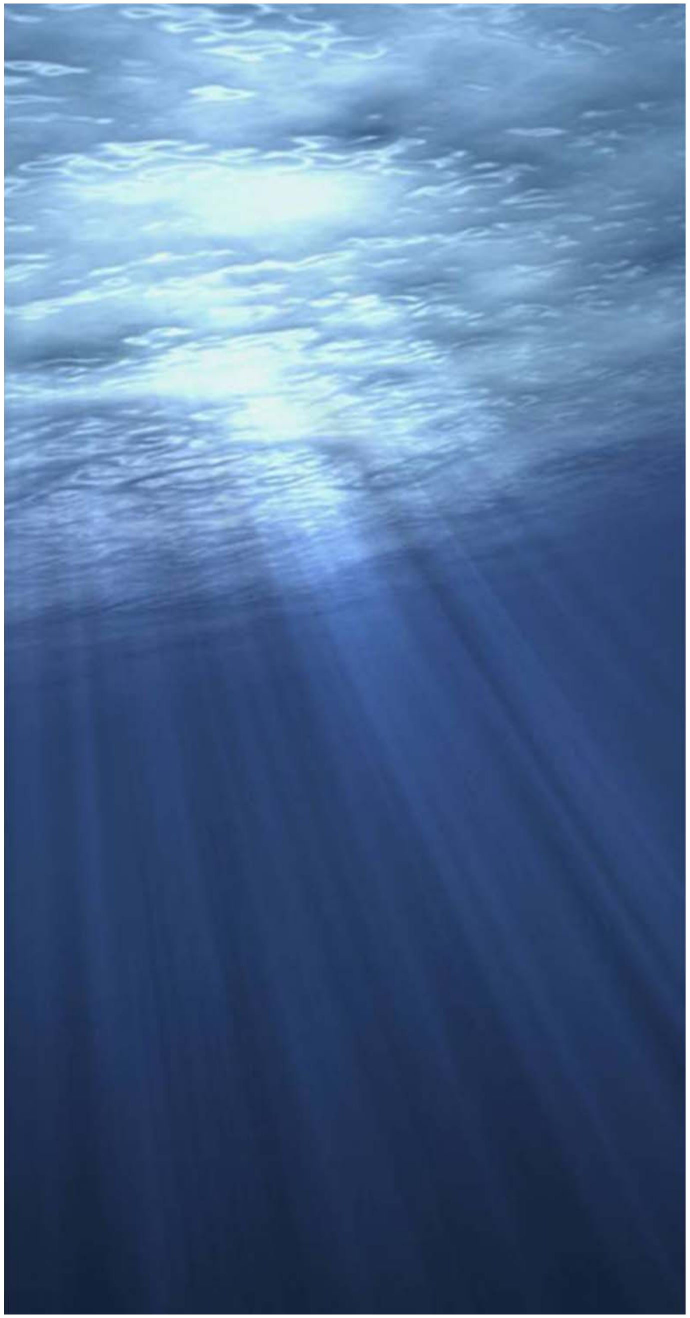


IVL Swedish Environmental Research Institute

An overview presentation

IVL Svenska Miljöinstitutet

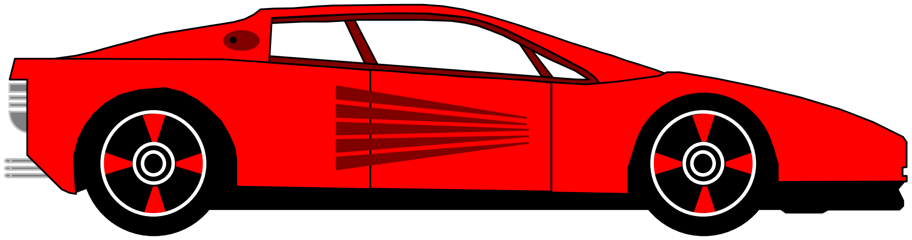
IVL – Swedish Environmental Research Institute

- **An independent non-profit research institute**
- **Turnover**
  – 204 MSEK 2009
- **Owner structure**
  – Co-ownership between the Swedish government and the Swedish industry (50%/50%) by a foundation
- **More than 40 years of experiance**
  – In development since 1966

Single object analysis

Emissions

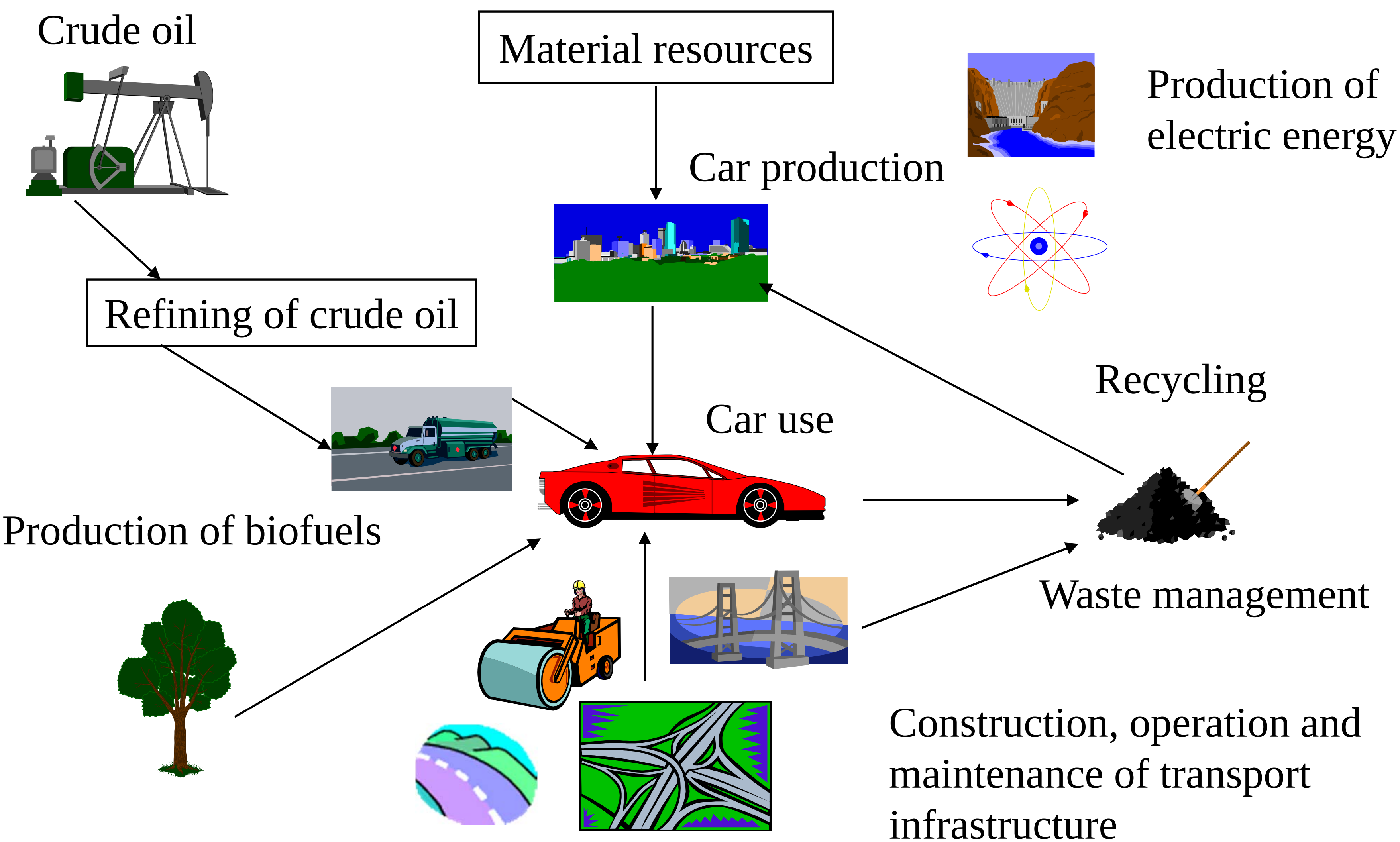
NO_X
HC
CO
Particles
etc.



Fuel use

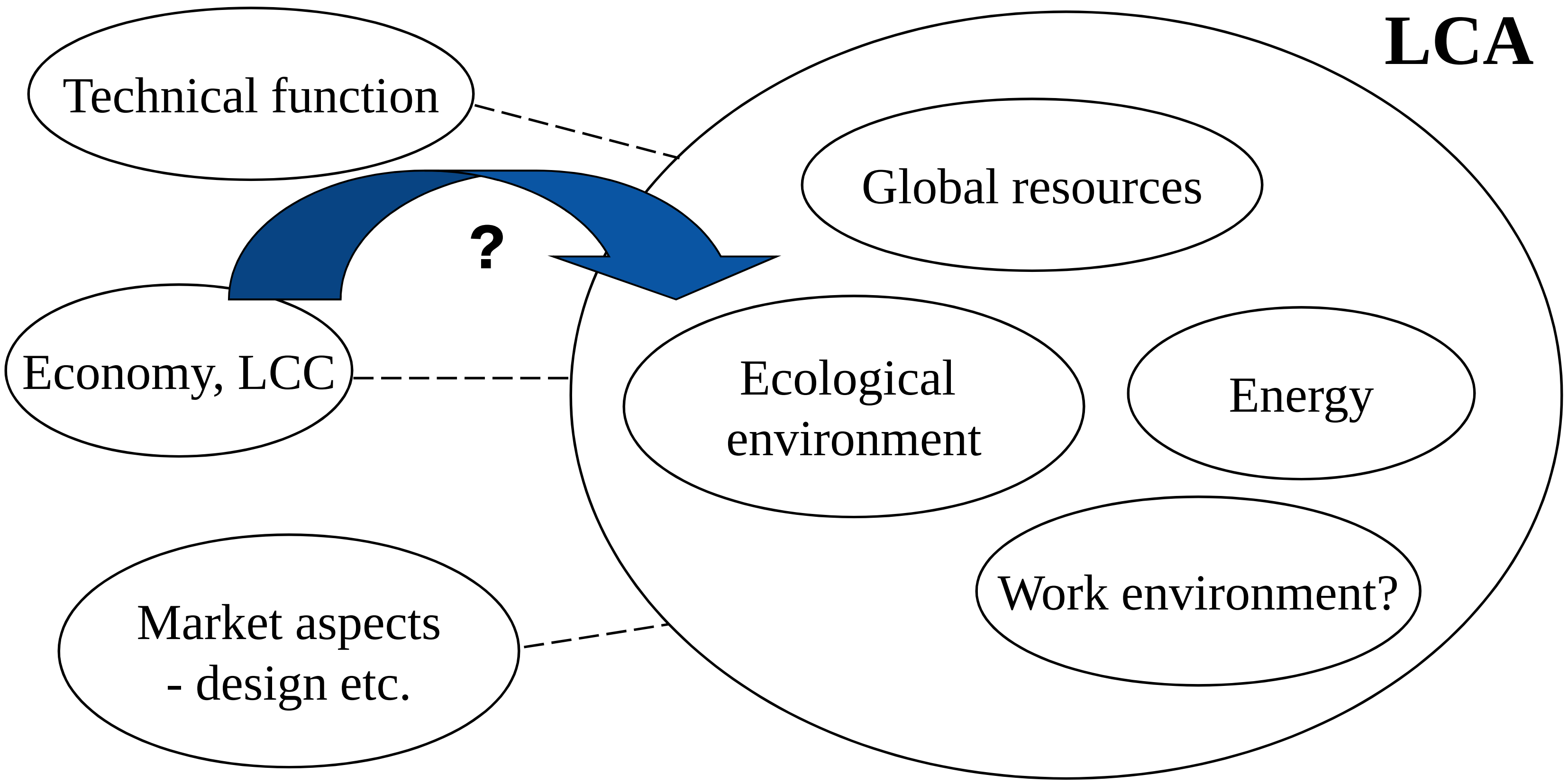
Gasoline
Diesel
Natural gas
Ethanol
Electric power
etc.

System analysis



LCA and LCC – tools and applications

- Energy analysis
- Resours analysis
- Emission analysis
- (Economic analysis – LCC)
  - Resolution
  - Calculation methods
  - External costs (e.g. environmental costs)


LCA
Technical function
Global resources
?
Economy, LCC
Ecological environment
Energy
Work environment?
Market aspects - design etc.

System analysis of transport infrastructure

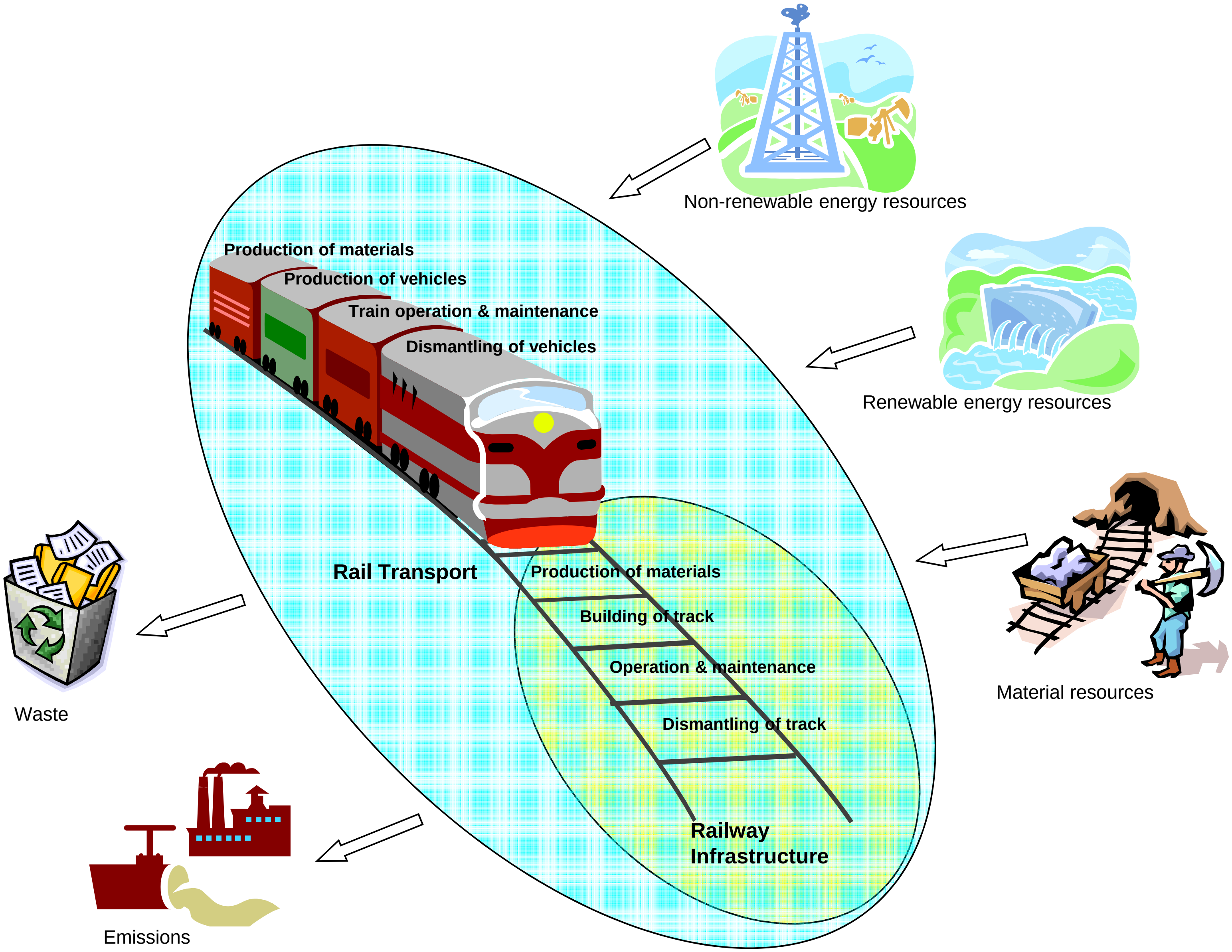
- Short overview – How does it start?
- Roads and road traffic
- Railways and train traffic
- Ports and shipping
- Airports and air traffic

LCA in a methodological perspective

- Strategic Environmental Assessment, SEA (Political and society strategic perspective, Strategisk miljöbedömning SMB)
- Environmental Impact Assessment, EIA (Project and site perspective, Miljökonsekvensbeskrivning MKB)
- **Life Cycle Assessment, LCA (product perspective)**
- Substance Flow Analysis, SFA (material and substance perspective)

Main principle of a full transport LCA

	Construction	Maintenance	Operation
Infrastructure			
Traffic			


Non-renewable energy resources
Renewable energy resources
Material resources
Production of materials
Production of vehicles
Train operation & maintenance
Dismantling of vehicles
Rail Transport
Production of materials
Building of track
Operation & maintenance
Dismantling of track
Railway
Infrastructure
Waste
Emissions

Railway track foundation. The service road is shown to the left.

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Railway in a rock cutting

Main railway tunnel

A steel girder railway bridge. To the right, the erosion protection of the slope is shown.

Railway systems are complex and require large LCA computer models. (In this case more than 32000 equations)

An LCA computer software (KCL-ECO) has been used.

Due to the complexity of the models, several general railway component models have been developed. The component models can then be integrated to form a large model of an entire railway system.

The component models (sub-models) are:

- Railway track foundation model
- Railway track model
- Railway electric power and control system model
- Railway tunnel model
- Railway bridge model
- Railway passenger station and freight terminal model
- Passenger and freight train model including train operation.

⇒ Collection of inventory data (LCI)

A single-track railway with sidings being laid from the bridge over Ångermanälven, north of Kramfors airport, via Örnsköldsvik, Husum, Nordmaling, to Umeå.

<u>Some specifications of the Bothnia Line:</u>

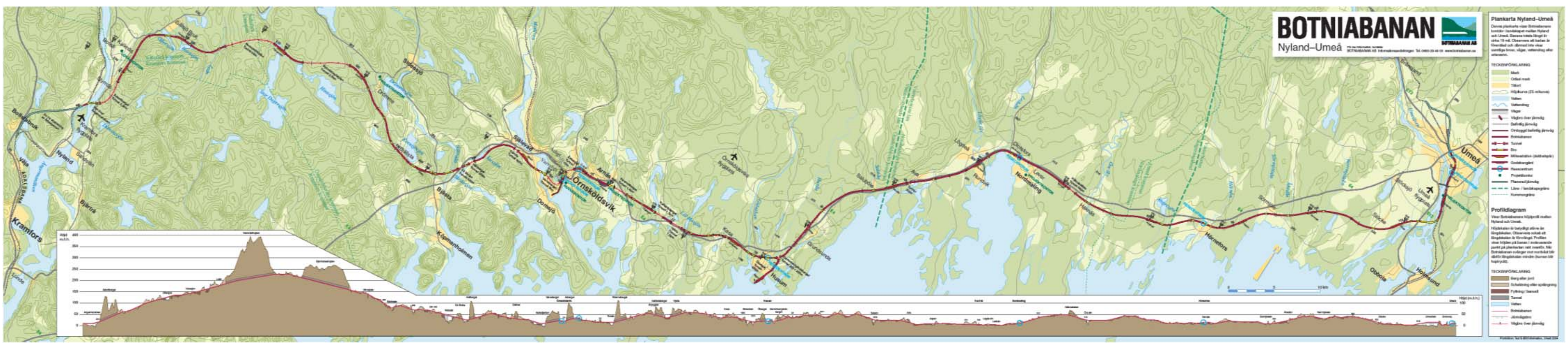
Total railway track length: 209 000 m

(of which main railway track is 183 000 m, side tracks are 23 000 m and shunting yard tracks are 3000 m)

Railway bridges: 90 railway bridges, in total 10 930 m

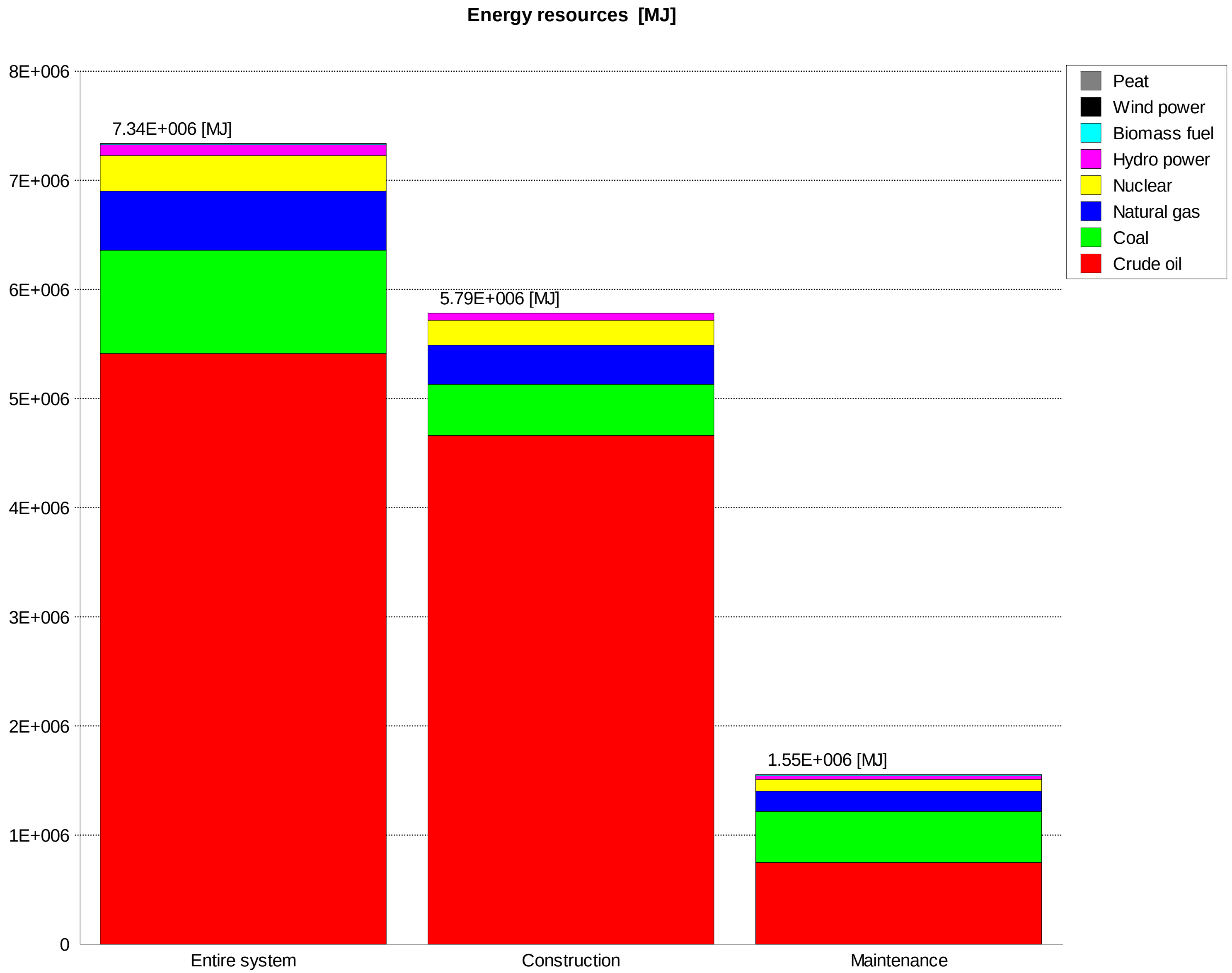
Railway tunnels: 16 railway tunnels, in total 24 538 m

Track foundation length: 209 000-10 930-24 538 = 173 532 m

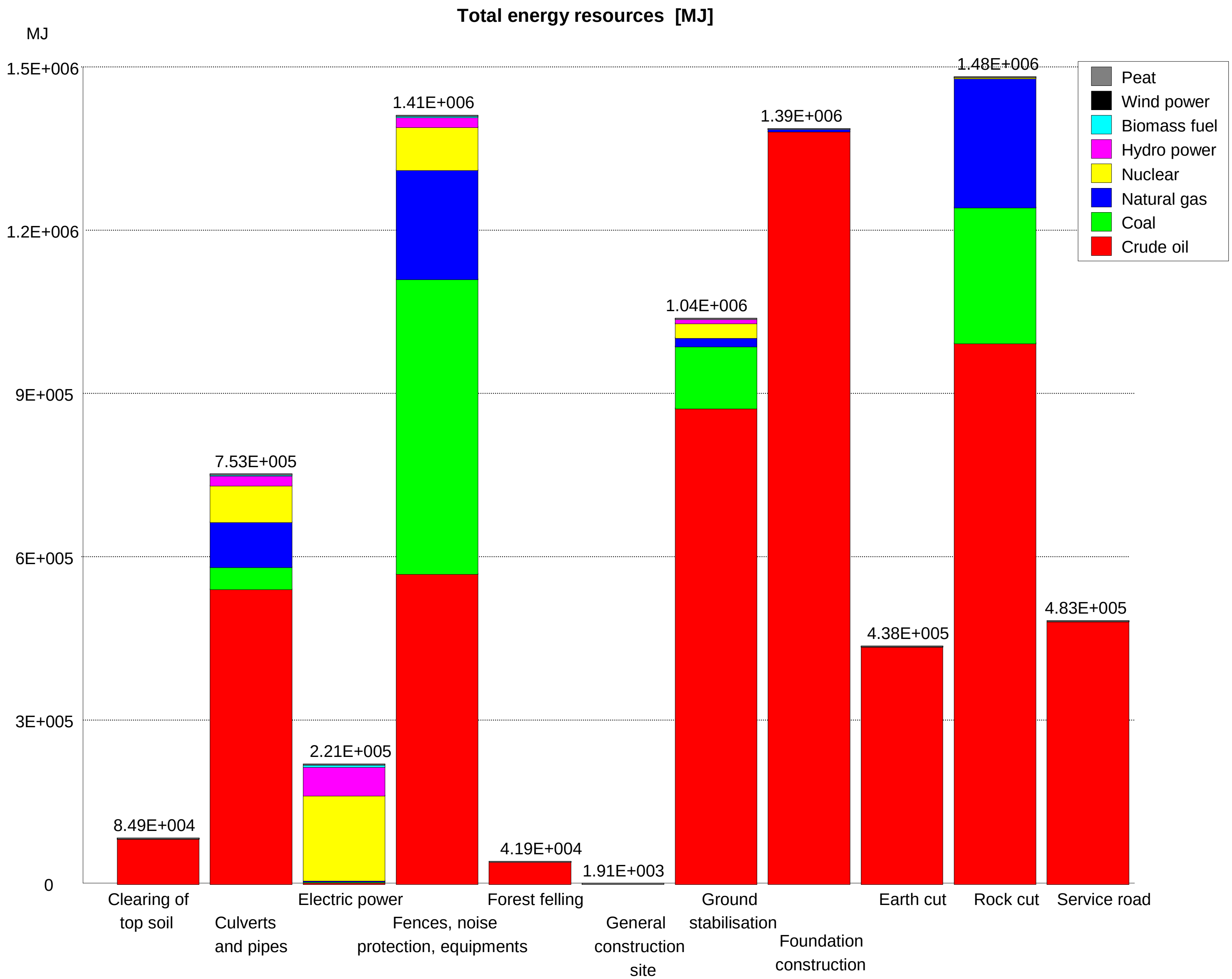


… and now a very short demonstration of an infrastructure LCA model

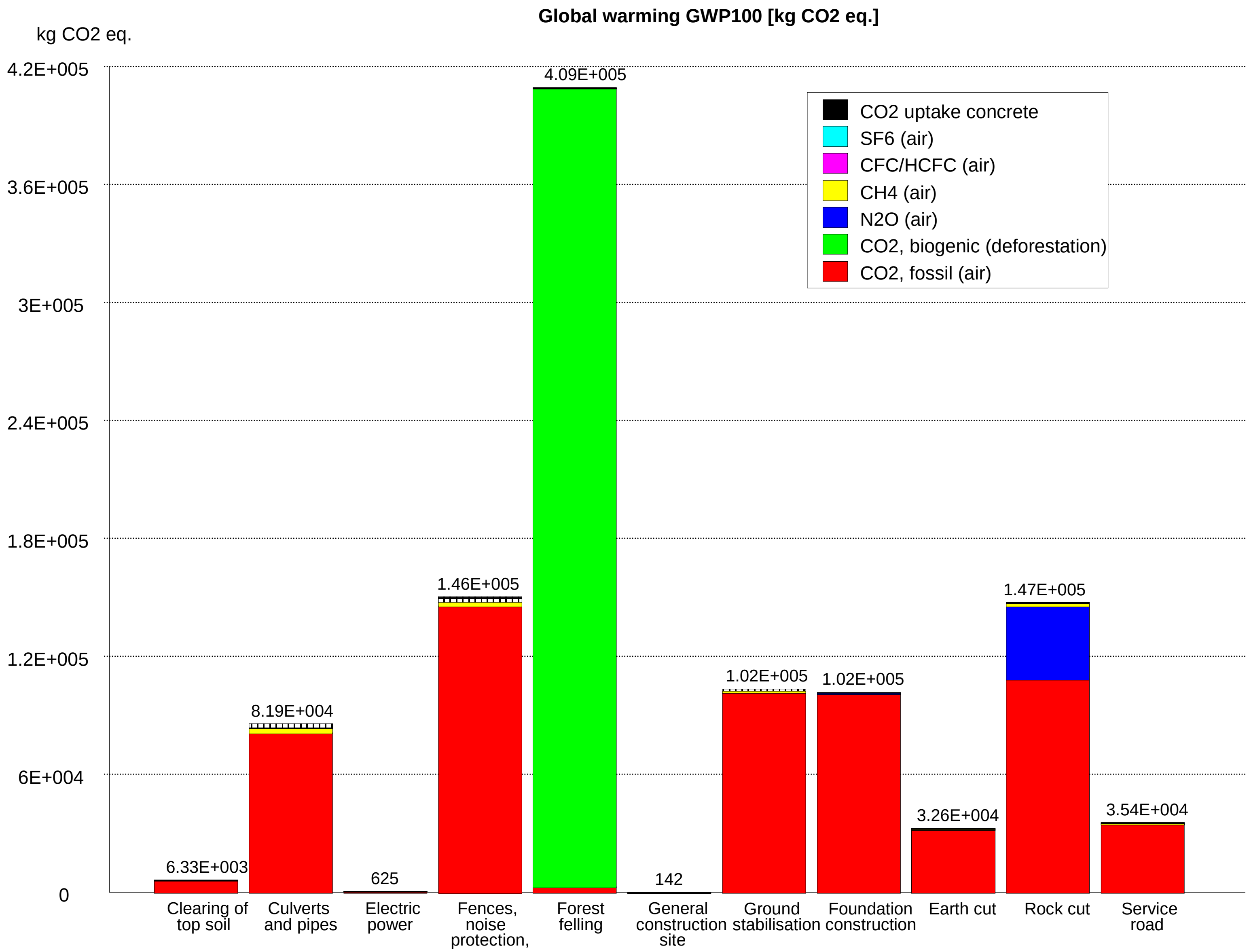
- A railway track foundation model



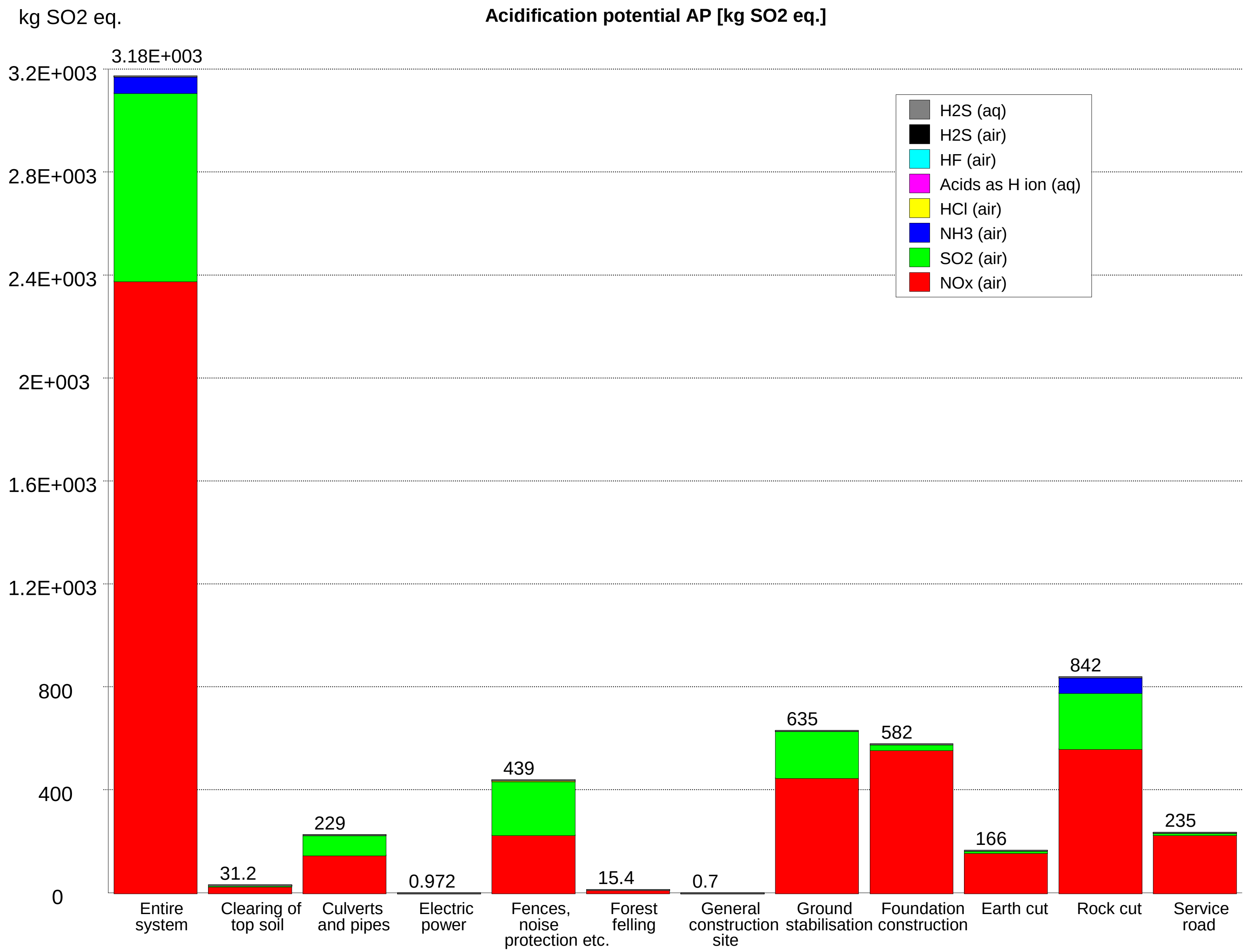
Use of energy resources for 1 km track foundation. The energy use is divided into construction, maintenance and operation and shows the results over a calculation period of 60 years. The track foundation has no energy use for operation.



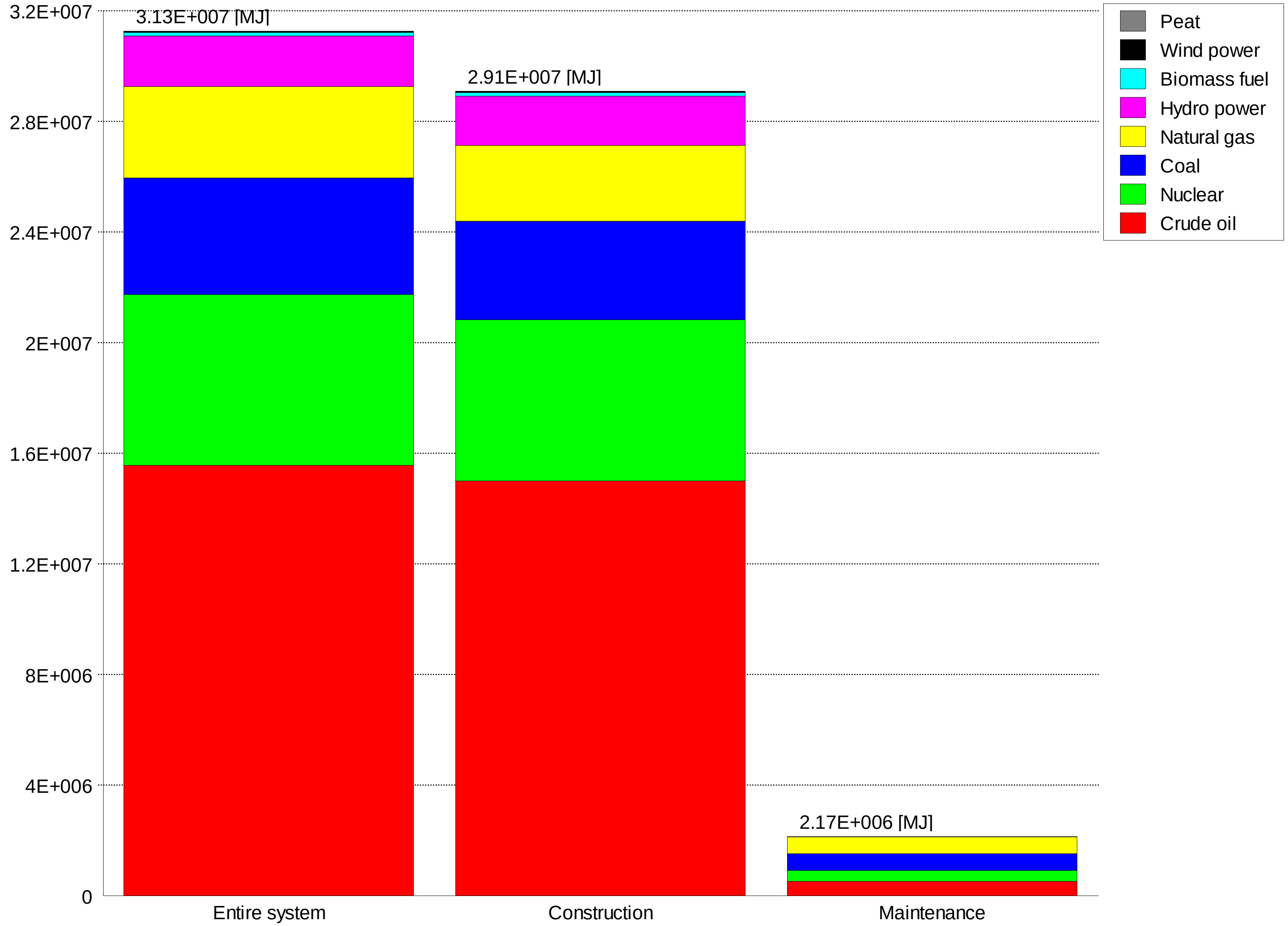
Use of energy resources for 1 km track foundation divided into different sub-processes. The figure includes construction, maintenance and operation over a calculation period of 60 years. The electric power use calculated in the model is shown separately.



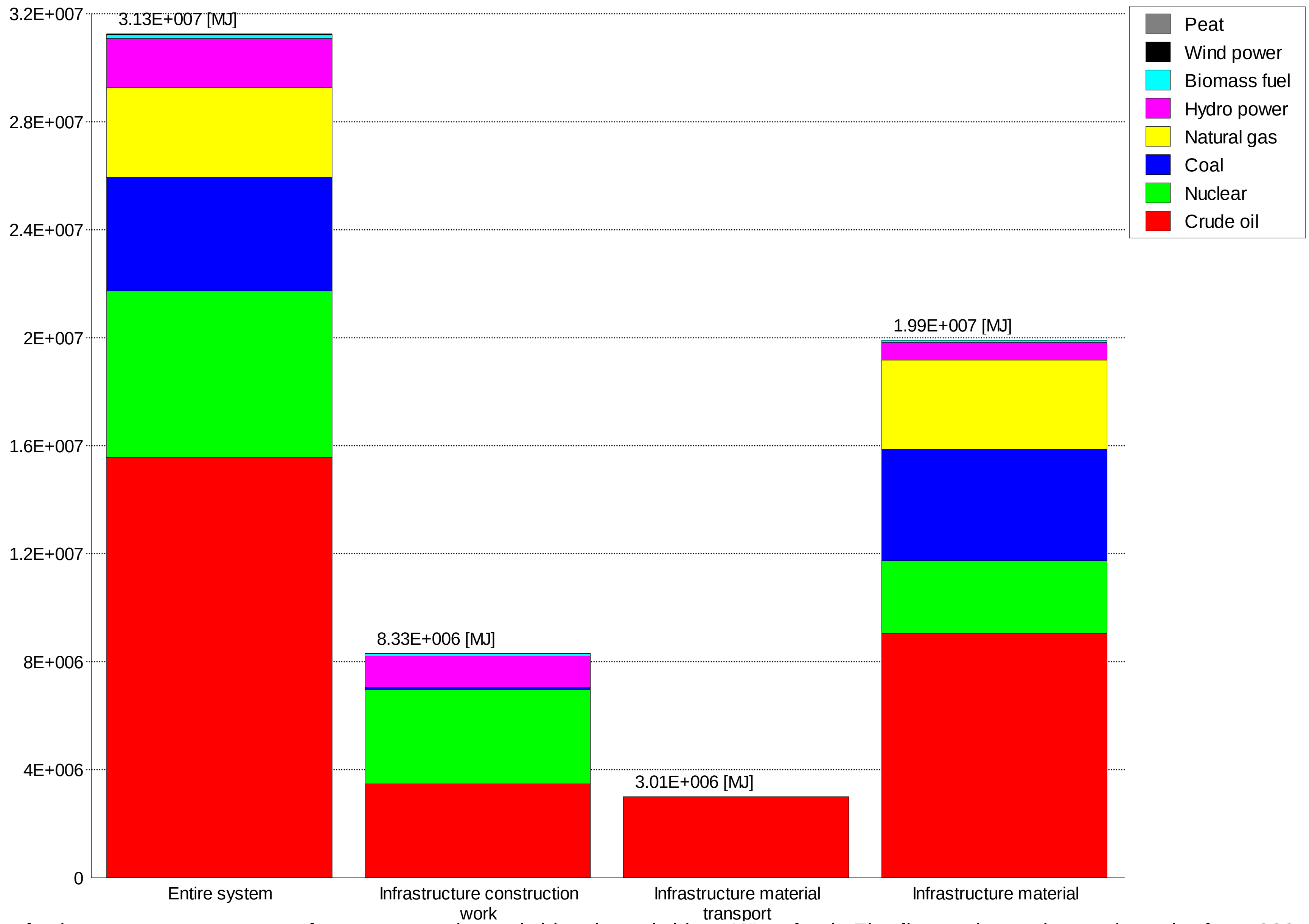
Greenhouse gas emissions from 1 km track foundation expressed as global warming potential (GWP). The figure shows GWP divided into different sub-processes. The results covers the entire life-cycle including construction, maintenance and operation over a calculation period of 60 years.



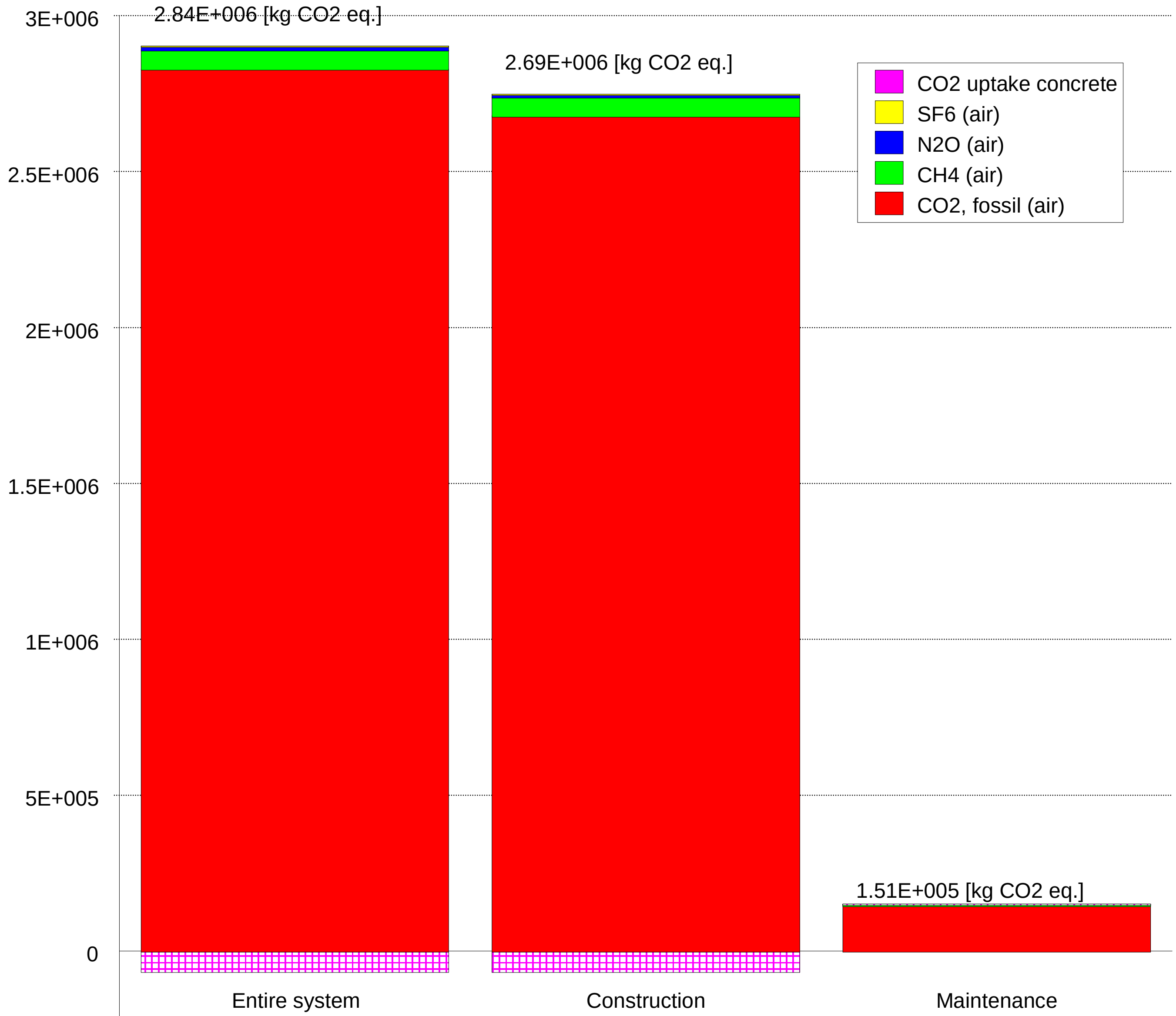
Emission of acidifying substances from 1 km track foundation expressed as acidification potential (kg SO_2 equivalents). The figure shows AP divided into different sub-processes. The results covers the entire life-cycle including construction, maintenance and operation over a calculation period of 60 years.



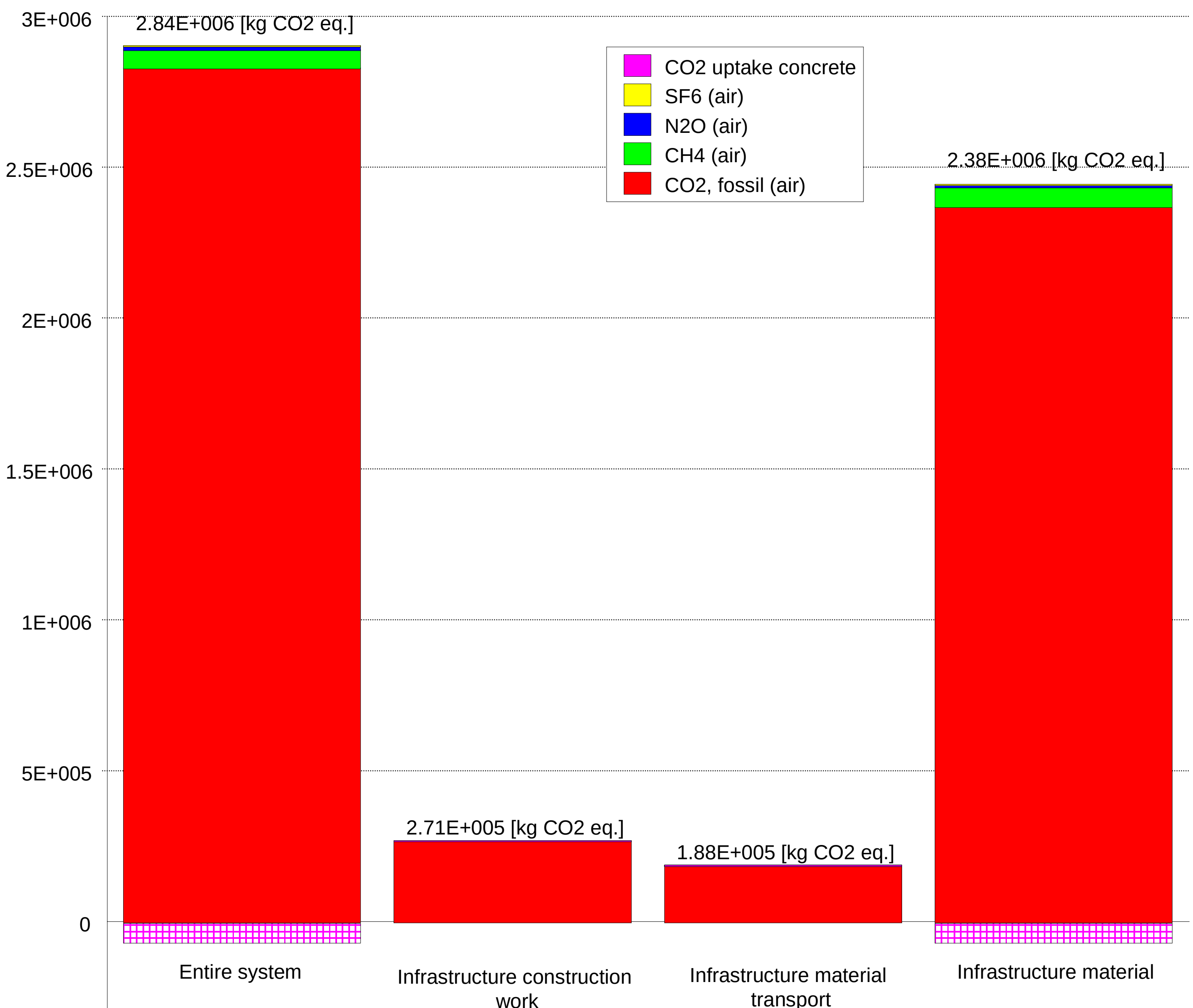
Use of primary energy resources for a concrete beam bridge (type bridge: Hörnefors). The figure shows the total results for a 389 m single track railway bridge. The energy use is divided into construction, maintenance and operation and shows the results over a calculation period of 60 years. No operation data exist for the bridge. The figure does not include the railway track (rail, sleeper and track ballast) and the train power and control systems.



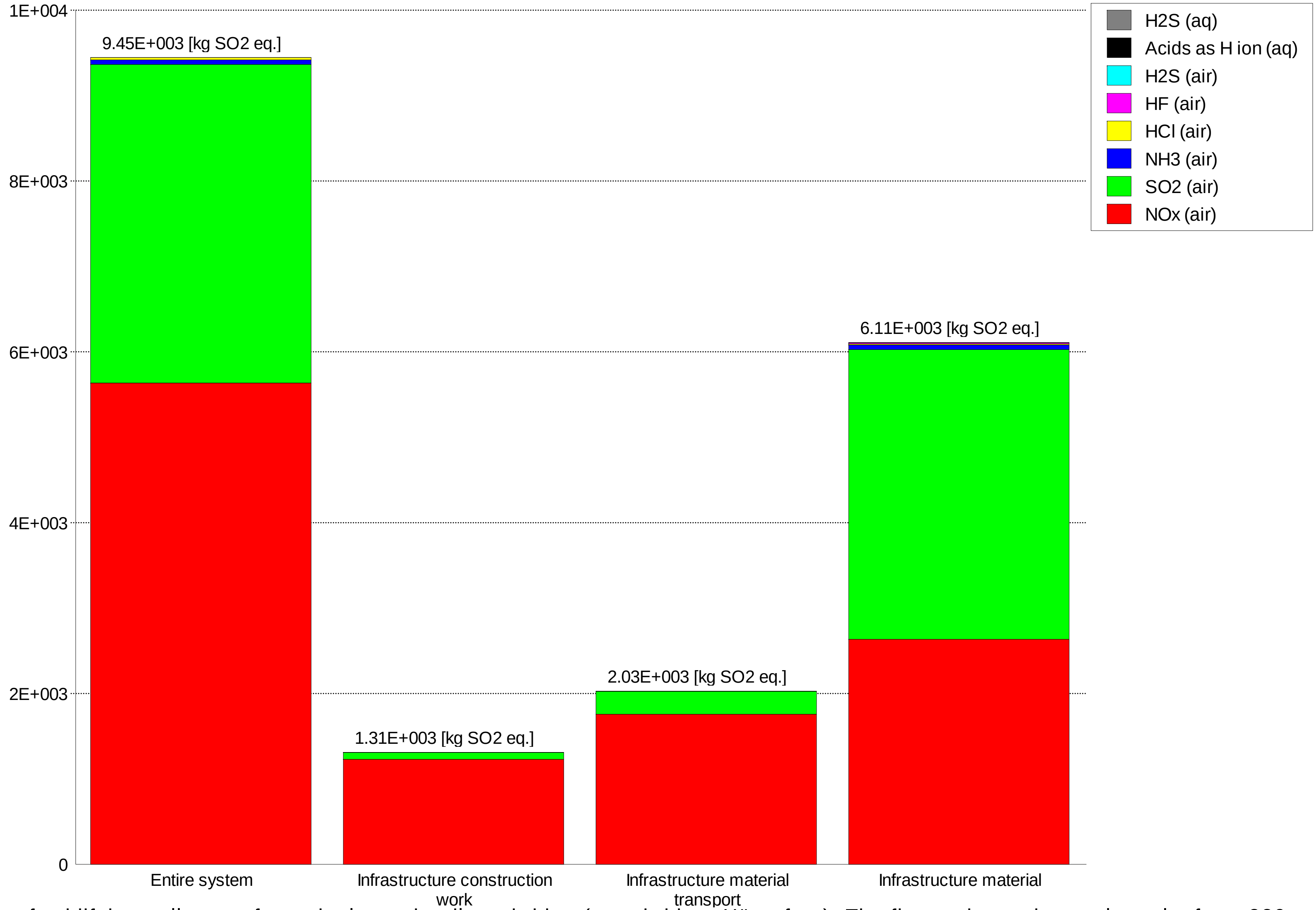
Use of primary energy resources for a concrete beam bridge (type bridge: Hörnefors). The figure shows the total results for a 389 m single track railway bridge. The energy use is divided into activity groups including construction, maintenance and operation and shows the results over a calculation period of 60 years. The figure does not include the railway track (rail, sleeper and track ballast) and the train power and control systems.



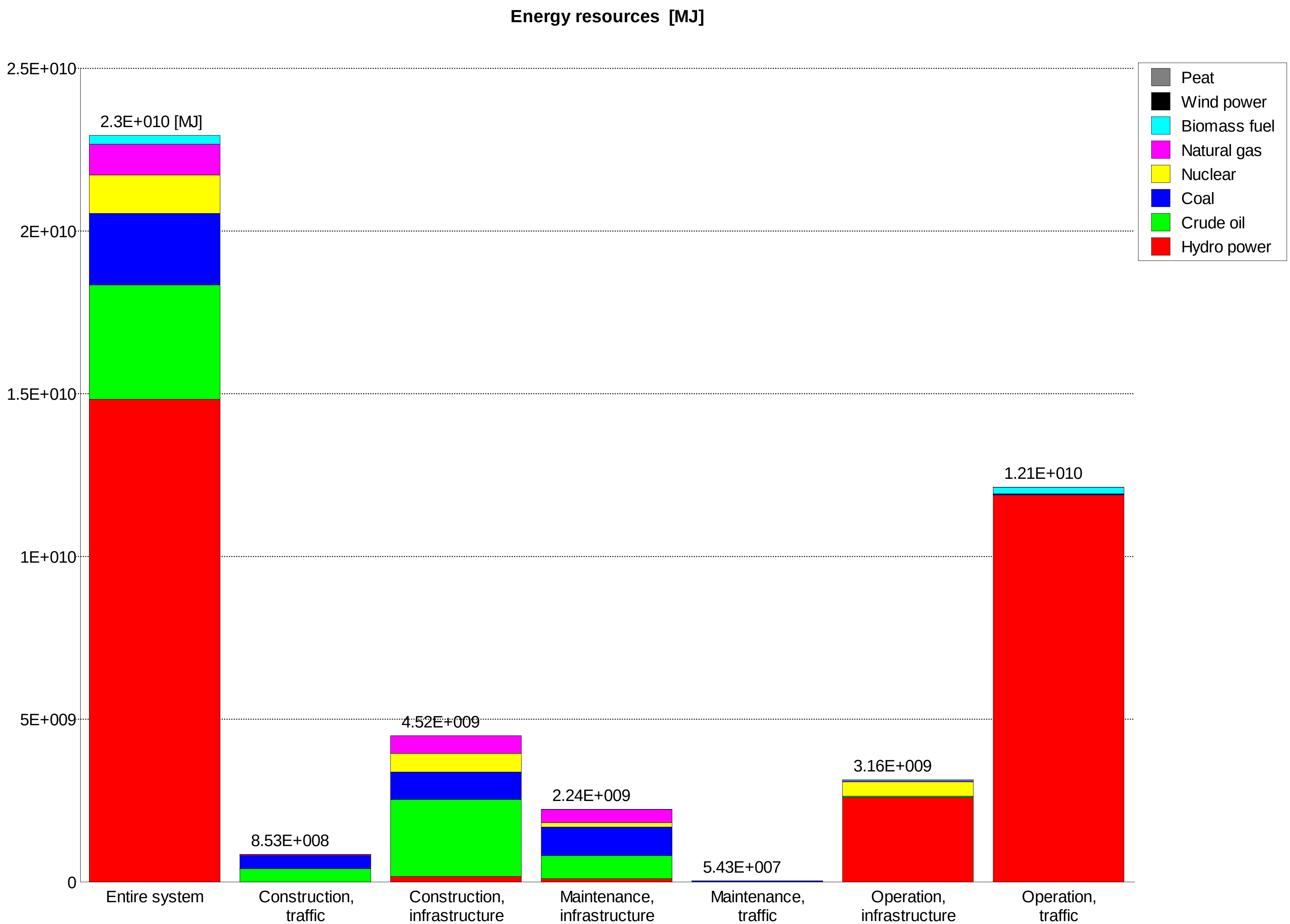
Emissions of greenhouse gases for a single track railway bridge (type bridge: Hörnefors). The figure shows the total results for a 389 m long bridge. The emissions are divided into construction, maintenance and operation and show the results over a calculation period of 60 years. No operation data exist for the bridge. The figure does not include the railway track (rail, sleeper and track ballast) and the train power and control systems. Uptake of CO2 in concrete during product use is shown as hatched negative values. The total sum is the net value when the uptake is subtracted.



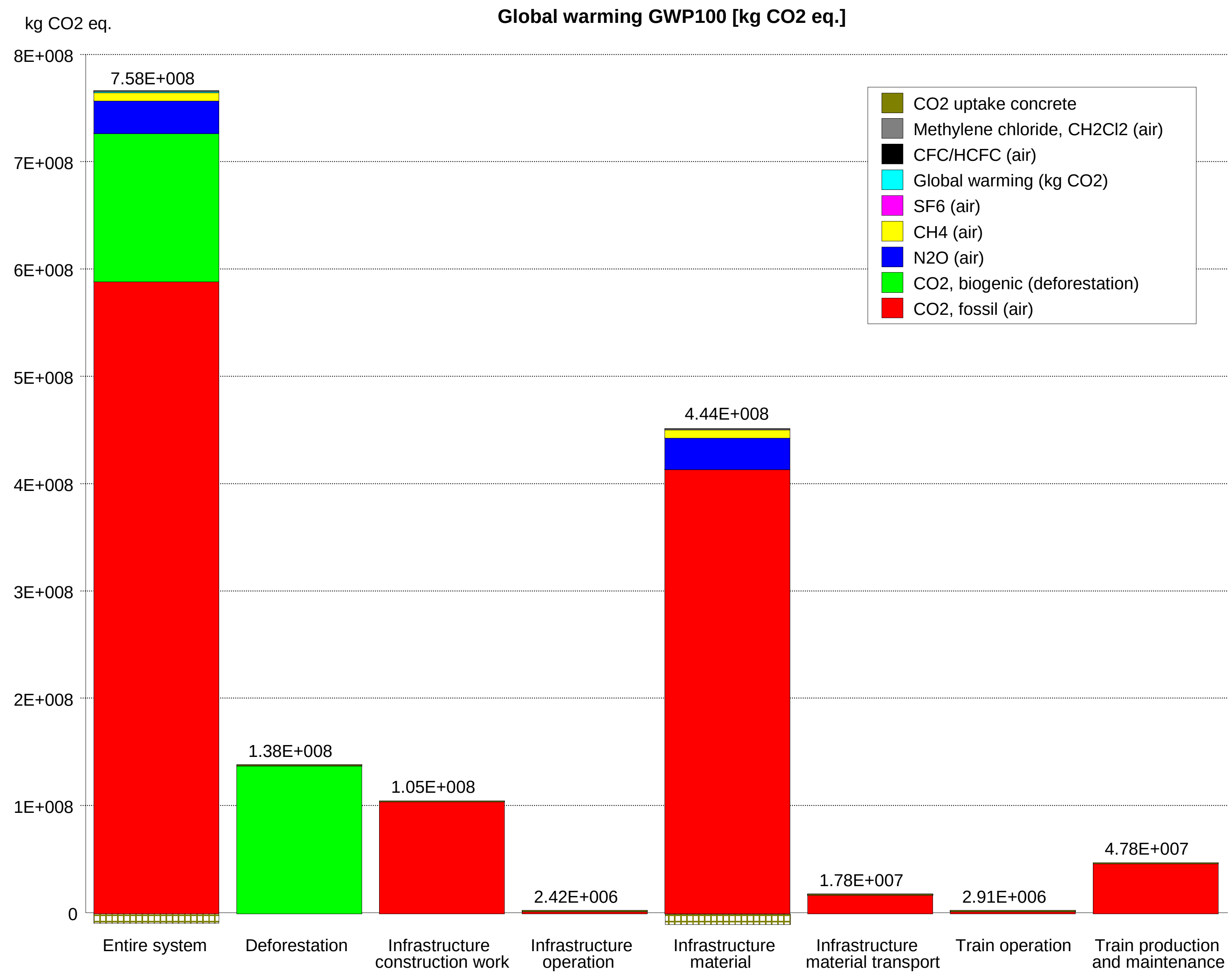
Emissions of greenhouse gases for a single track railway bridge (type bridge: Hörnefors). The figure shows the total results for a 389 m long bridge. The emissions are divided into activity groups including construction, maintenance and operation and show the results over a calculation period of 60 years. The figure does not include the railway track (rail, sleeper and track ballast) and the train power and control systems. Uptake of CO2 in concrete during product use is shown as hatched negative values. The total sum is the net value when the uptake is subtracted.



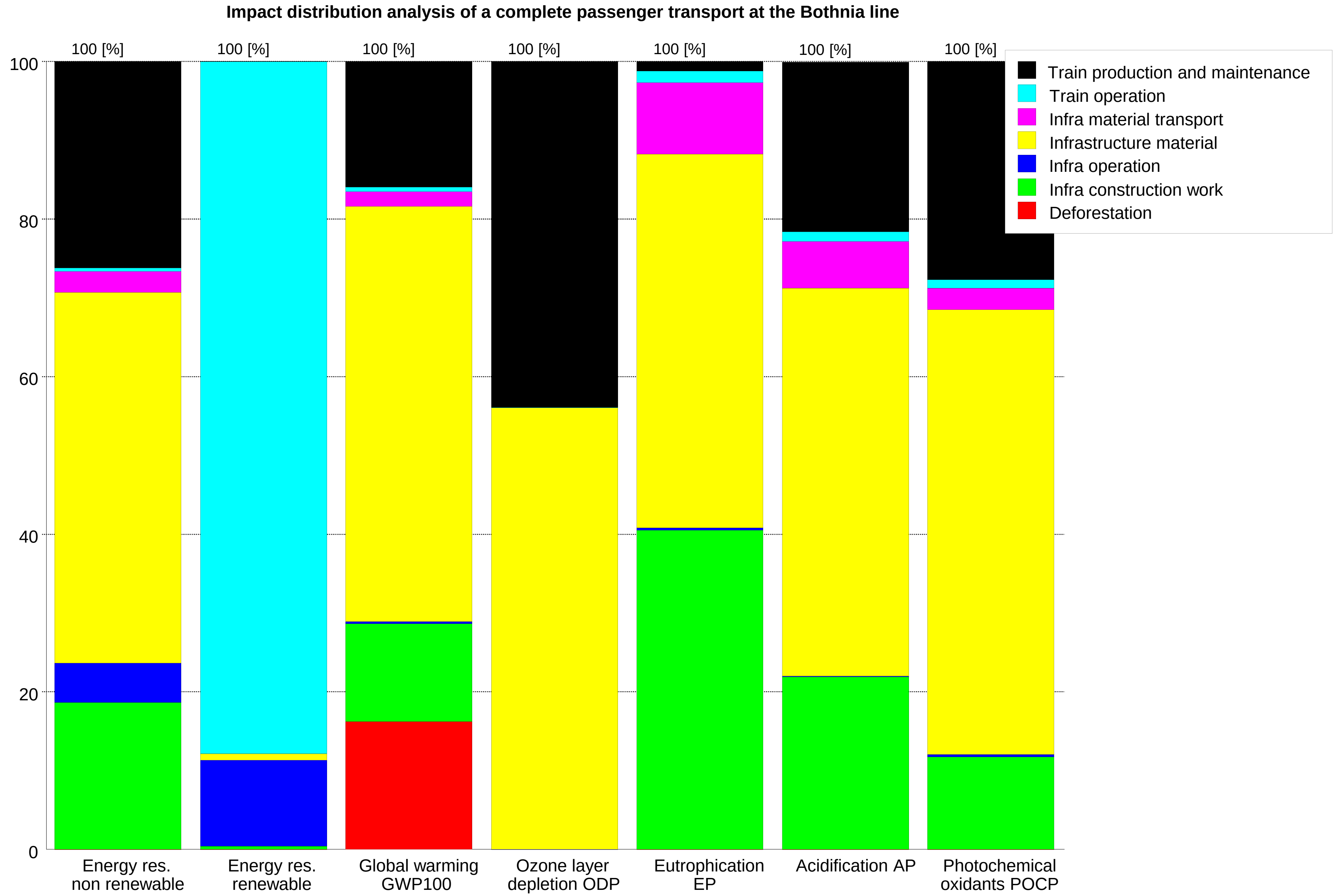
Emissions of acidifying pollutants for a single track railway bridge (type bridge: Hörnefors). The figure shows the total results for a 389 m long bridge. The emissions are divided into activity groups including construction, maintenance and operation and show the results over a calculation period of 60 years. The figure does not include the railway track (rail, sleeper and track ballast) and the train power and control systems.



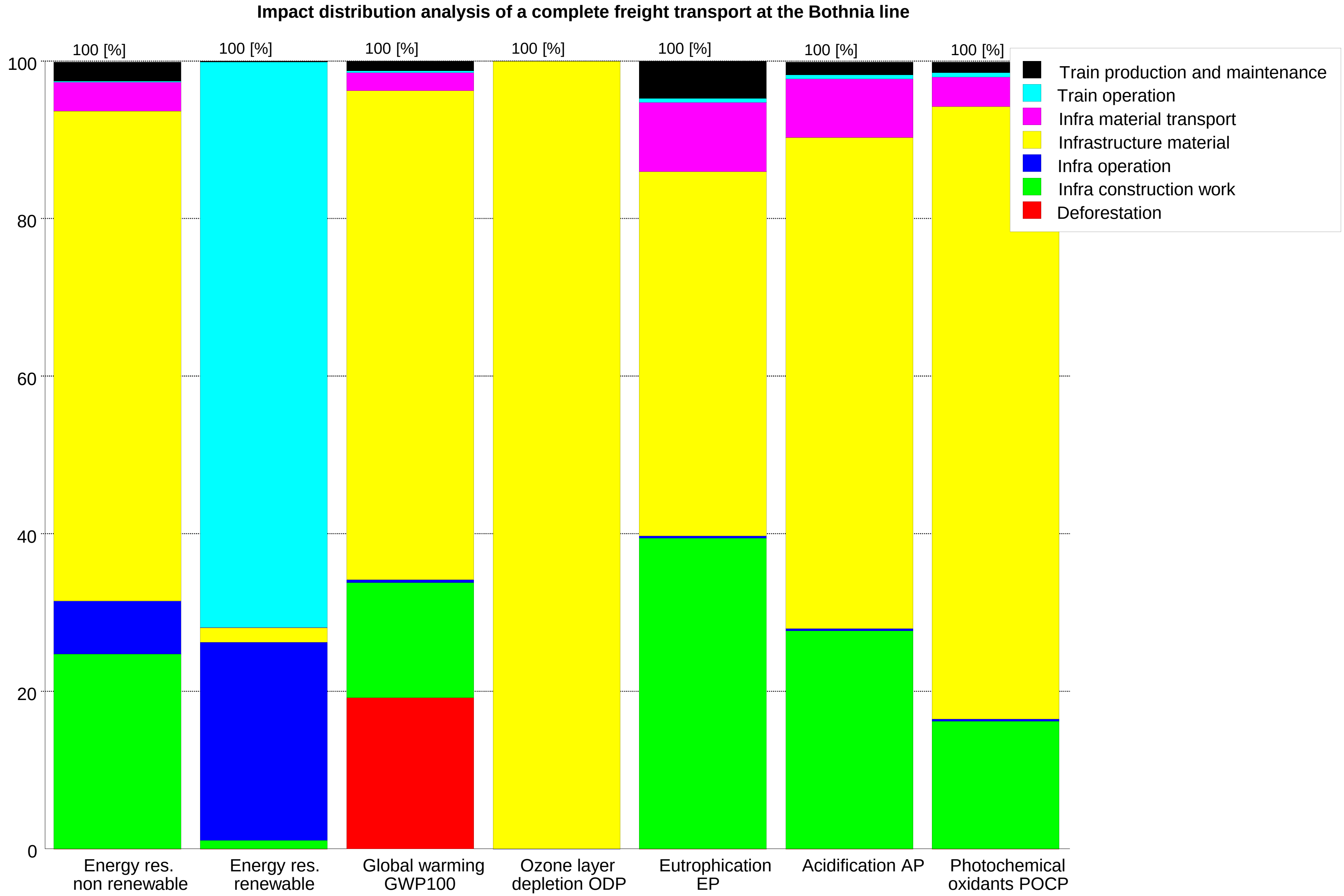
Use of primary energy resources for the Bothnia Line. The figure shows the total results including all parts of the railway infrastructure and the transport work (the traffic, freight and passenger) over a calculation period of 60 years.



Emissions of greenhouse gases for the Bothnia Line. The figure shows the total emissions including all parts of the railway infrastructure and the transport work (the traffic, freight and passenger) over a calculation period of 60 years. Green electric power is used.



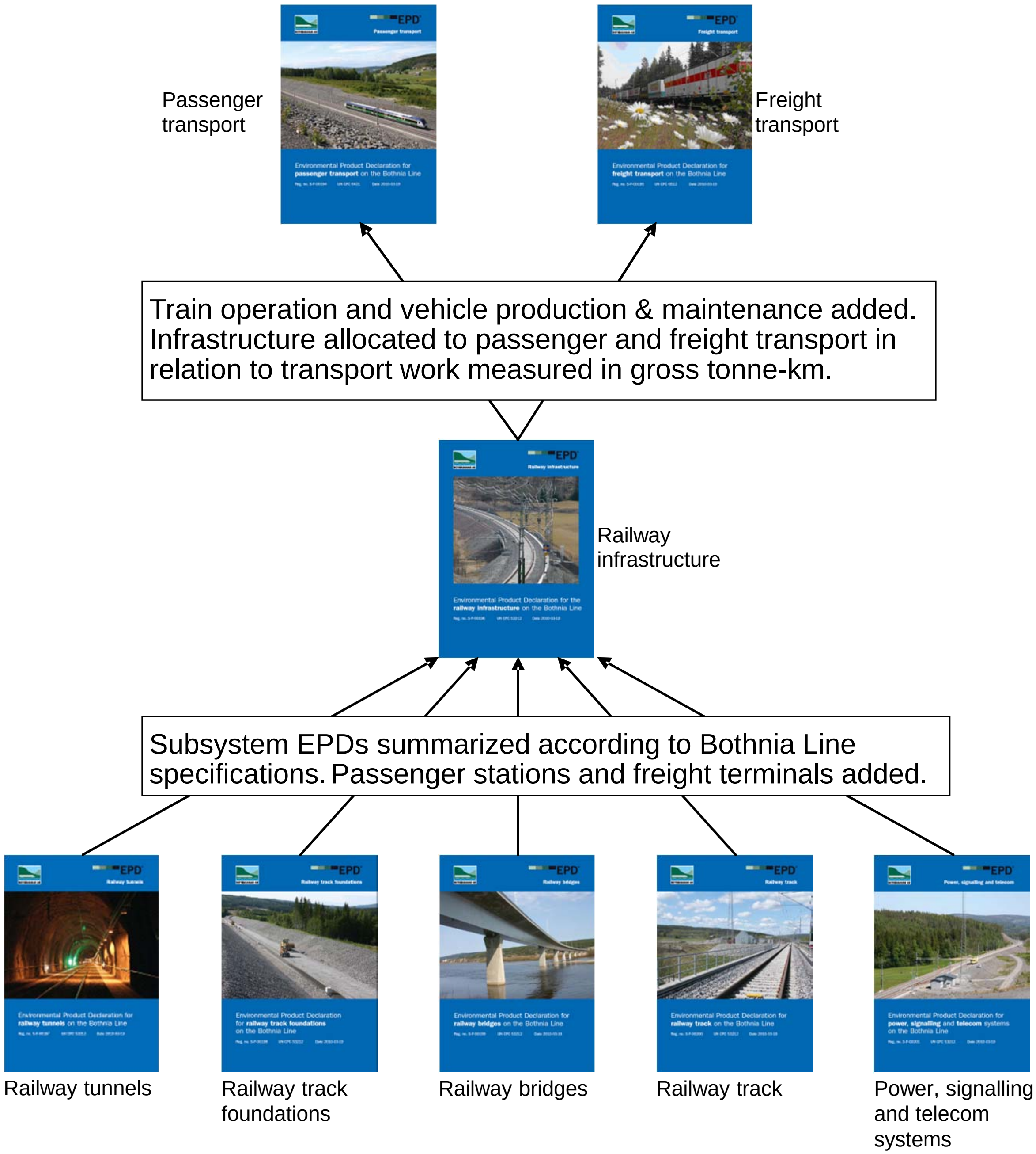
Impact distribution analysis of a complete passenger transport at the Bothnia Line.

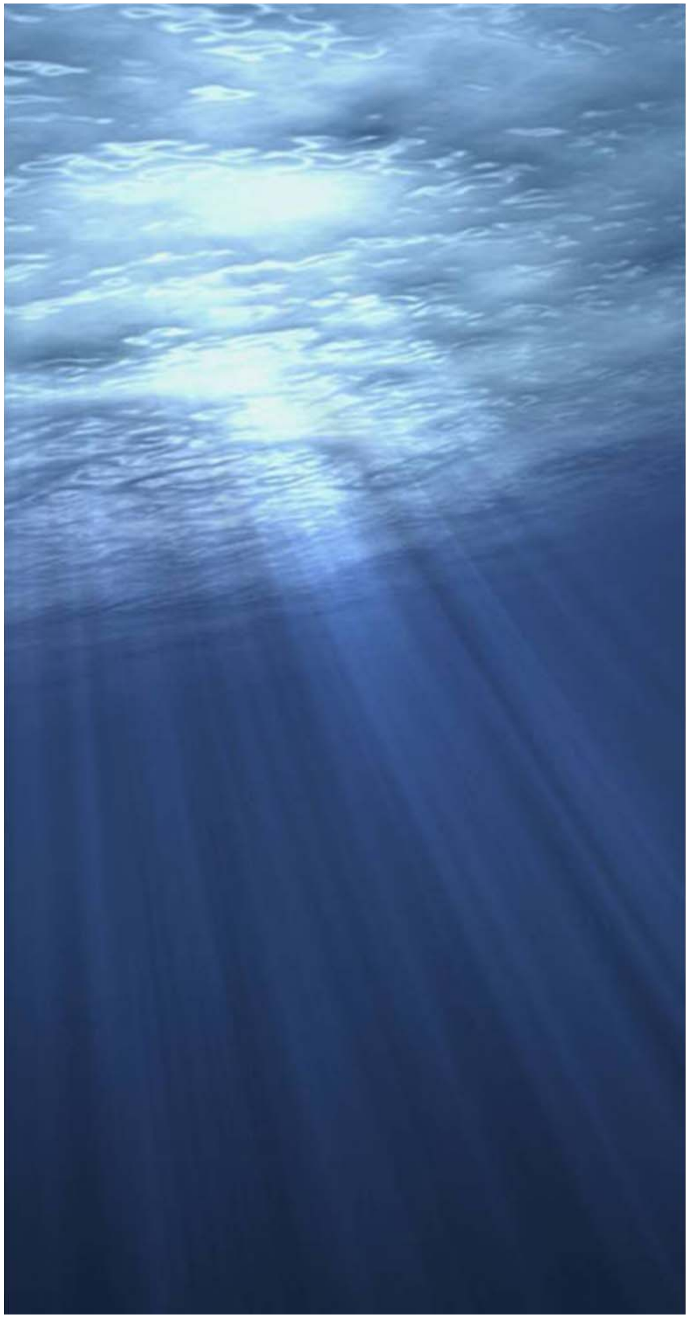


Impact distribution analysis of a complete freight transport at the Bothnia Line.

Detailed dominance analysis for the contribution of infrastructure material to the environmental impact category Global warming.

Material / subsystem	Track	Tunnels	Bridges	Stations	Track Foundations	Power, signalling, telecom	Total
Steel	29 %	4 %	5 %		3 %	3 %	43 %
Cement	6 %	10 %	11 %		5 %	0 %	32 %
Buildings				11 %			11 %
Aluminium						4 %	4 %
Explosives	0 %	2 %			1 %		3 %
Plastics	0 %	1 %			1 %	1 %	2 %
Copper						1 %	1 %
Total	**35 %**	**16 %**	**16 %**	**11 %**	**10 %**	**9 %**	**97 %**


Passenger transport
Freight transport
Train operation and vehicle production & maintenance added. Infrastructure allocated to passenger and freight transport in relation to transport work measured in gross tonne-km.
Railway infrastructure
Subsystem EPDs summarized according to Bothnia Line specifications. Passenger stations and freight terminals added.
Railway tunnels
Railway track foundations
Railway bridges
Railway track
Power, signalling and telecom systems



Thanks for your attention!

www.ivl.se

The report can be downloaded from the homepage:

Stripple H., Uppenberg S., Life cycle assessment of railways and rail transports - Application in environmental product declarations (EPDs) for the Bothnia Line, IVL report B1943 (2010).