Nederlands kenniscentrum voor ondergronds bouwen en ondergronds ruimtegebruik

Towards a zero-energy tunnel: 5 roads to discuss

Let's talk, discuss and improve. Please contact us at www.cob.nl, karin.dehaas@cob.nl or 0031 6 5429 1940

With the energy reduction catalogue made in the Netherlands (see www.cob.nl/groeiboek/energiereductie) we claim to be able to develop and renovate tunnels with a 50% energy reduction. But how should we move towards a zero-energy tunnel? We have five main roads we would like to discuss, develop and walk with an international network. Will you join in?

1. Adaptive and smart lighting

The lighting system determines to a large extent the energy consumption of a tunnel. This means that reduction of energy consumption through lighting directly results in a big profit. Therefore, the first line of research is aimed at reducing these energy consumers.

Short term (2017-2020)

- We want to do research on all the aspects of adaptive lighting. It is necessary to look beyond pure technology, because we have insufficient knowledge in the field of experience, psychology and the functioning of the eye. Which luminance level is required in order to make sufficient contrast in case of new lighting concepts. Can we gain insight into the psychological aspects of tunnel visibility? Is there a difference in the desired luminance level in day and night situation? What are the conditions for adaptive lighting and what is the definition of adaptivity in a modularly constructed tunnel system? What can be the reflective function of wall and floor in tunnels?
- We create a high level of energy reduction with the reintroduction of light-screens at the entrance and exit of tunnels, but this structural solution requires smart solutions that can quickly be integrated into existing constructions and design, smart use of other civil structures in the surrounding, easy to maintain, good to combine with local power generation and don't affect the safety -and availability level of the tunnel.
- We start this year with the placement of solar panels on tunnels and service buildings in the Netherlands for local power generation.

Long term (2020-2030)

- In which way can new lighting systems, as already developed for social security, contribute to road safety of tunnels from the perspective of the user?
- How can we introduce self-luminous light concepts by using big data, which permanently reduces energy consumption in combination with predictable and minimal maintenance?
- What luminance level is required for autonomous cars to drive safely through a tunnel?

2. From AC to DC-Network

Current electronics works largely on DC (direct current). In addition, most of the renewable energy sources also supply DC. In tunnels, we see that, next to the large amount of electronics, the lighting systems also operates on a DC network. This calls for an examination of the current energy network based on alternating current, AC. We see added values and opportunities for using DC-networks. This does not only lead to a reduction in the transformation losses but the equipment within the tunnel will also be smarter and with less components. In addition, 'non-durable' components such as batteries and transformers will no longer be needed. Unfortunately, today's electronic systems and interfaces are not ready yet for this implementation.

Short term (2017-2020)

- What are the preconditions (both technical and non-technical) that a DC network should meet to be suitable for use in tunnels?
- What are the preconditions (both technical and non-technical) that need to be imposed on systems and interfaces to make them suitable for use in a DC network in tunnels?
- Which systems and interfaces are best suitable for use in tunnels?

Long term (2020-2030)

To be decided later.

3. The smart tunnel as part of a smart grid

Sustainable local power generation and energy storage have gained momentum and offer opportunities for the development of smart tunnels. How can the tunnel become part of a smart grid and what conditions should local power generation and power storage meet to accommodate these vulnerable infra-objects? What is actually the definition of a smart, adaptive tunnel if we desire in the future a zero energy tunnel? Are self-learning systems a solution for the large energy consumers such as fans in the tunnel? How can we simplify traffic management and speed reduction systems?

Short term (2017-2020)

- Setting the agenda for the tunnel aspects in already developed / to be developed tracks around smart grids, such as the Amsterdam Sustainable Initiative and the implementation of the Environmental Act (role of decentralized authorities).
- Formulate prerequisites for integrating tunnels into a (already existing or new-to-build) smart grid.
- What conditions should local power generation and storage fulfil to make them suitable for use in tunnels?
- Can the next generation of photonics sensor technology be a partial solution towards the zero energy tunnel?

Long term (2020-2030)

- What opportunities does a tunnel provide for energy generation and storage?
- In case of a downgrade of the tunnel, for example if smart mobility lowers down the safety requirements, how can we turn off those large energy consumers or create new concepts that combine features?
- Can hydrogen act as a source regarding to durability and safety?

4. Lifecycle asset management and energy reduction

Asset management of infrastructural works is still in its infancy and tunnels are no exception. Although this topic is wider than energy reduction, it is important to take also asset management into account. Therefore, the most important design shift is that tunnel usage is a key factor in design choices. When this shift is applied, it is important to take energy reduction during all stages of tunnel construction into account. As stated in the long-term vision of tunnels, energy reduction is mainly about adaptivity. Adaptivity is an opportunity to work from a tunnel that costs energy, towards a tunnel that generates energy.

Short term (2017-2020)

- Incorporating the theme of energy reduction in our range of measures in such a way that also the construction and demolition phase are taken into account.
- How do we ensure that functionality, security, availability and sustainability are brought in balance with standards, policies and laws?
- Can we implement the use of CO2-neutral concrete in tunnel construction projects as part of sustainable purchasing?

Long term (2020-2030)

- How does the changing function and traffic influence the energy consumption of a tunnel?
- What other functions beside the network function can be found in a tunnel? (water transport/storage)?
- What should be done to transform the tunnel into a self-learning system by using big data?

5. Playing together in a safe environment

To make a vulnerable object like a tunnel adaptable, we need to work together on a virtual playing field in which we can practice, test, verify and finally validate. Developments in the field of big data make this kind of playing field much easier. In this environment we can, first at concept level and later at a detail level, explore what the potential profit is and what the issues are which we need to take into account.

Short term (2017-2020)

- Can we stimulate the creation of a virtual playing field from the ambition of a zero- energy tunnel?
- Can we use that virtual play field to get a grip on the human factors? By for example using augmented reality, for insight into the actual visibility and safety of tunnels?
- Can we look at our virtual playing field to renovation projects on network or national level and looking for value creation instead of simply recovering what's up?

Long term (2020-2030)

- How can the playing field be adapted so that we are able to work with non-experts on spatial and security issues?
- How can our contract forms reflect the developing character of this task?