CEDR Transnational Road Research Programme
Call 2015: Climate Change: From desk to Road

funded by Germany, Netherlands, Ireland, Norway, Sweden and Austria

Decision-support Tools for Embedding Climate Change Thinking on Roads (DeTECToR)

Guidance on embedding climate change into operations and procurement

Deliverable 6.2
April, 2019

Prepared by TRL, AC, HI, IBDiM, CEC and AIT

With contributions from UBIMET and DWD

PEB members: Reinhard David (ASFINAG) (Project Manager), Martin Klose (BASt) (Deputy Project Manager), Billy O'Keeffe (TII), Gordana Petkovic (Vegvesen), Hakan Johansson (Trafikverket), Hanna Eklof (Trafikverket), Kees van Muiswinkel (RWS), Vincent O'Malley (TII), Paul Fortuin (RWS)

CEDR Call 2015: Climate Change
DeTECToR
Decision-support Tools for Embedding Climate Change Thinking on Roads

Draft guidance on embedding climate change in operations and procurement

Submission date: 30/04/2019

Start date of project: 01/09/2016 End date of project: 30/04/2019

Author(s) this deliverable:
Ewa Zofka (IBDiM, Poland), Thomas Buckland (TRL, UK), Sarah Reeves (TRL, UK), Andreas Leupold (AC), Arne Spekat (CEC), Marek Skakuj (HI), Christian Stefan (AIT)

PEB Project Manager: Reinhard David, ASFINAG, Austria

Version: 30.04.2019

Table of contents

Glossary

Term/Acronym	Definition
Adaptive management	A long-established approach that uses monitoring, research, evaluation and iterative development to improve future management strategies.
Climate	Climate can be defined as the average weather, normally over 30 years. It is the statistical description of the mean and variability of relevant variables such as temperature and precipitation.
Climate change	A change in the state of the climate that can be identified by changes in the mean and/or variability of it properties and persists for an extended period *(e.g. decades or longer).
Climate change adaptation	The adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.
Climate change mitigation	A human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs).
Climate projection	A projection of the response of the climate system to emissions or concentration scenarios of greenhouse gases and aerosols or radiative forcing scenarios, often based upon simulations of climate models. (IPCC)
Cost-benefit analysis (CBA)	An analytical methodology for the quantification of the positive and negative consequences of a project in monetary terms over a set appraisal period.
Environmental Product Declaration (EPD)	An EPD is an independently verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of products.
Greenhouse Gas (GHG)	Gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. (IPCC)
National Road Administration (NRAs)	The organisations which manage the construction, maintenance and operation of a countries main roads.
Programme Executive Board (PEB)	The PEB consists of representatives of the NRAs funding a particular CEDR research programme. It oversees and steers the research projects within the programme.
Risk	ISO 31000 describes risk as the effect of uncertainty on objectives. In engineering terms risk is often described as a combination of the likelihood of an event occurring and the magnitude of the consequences if it does occur. When considering climate change, likelihood is related to exposure to environmental conditions and the vulnerability of the asset.
Uncertainty	A state of limited knowledge with difficulty in describing the current state of future outcome.
Weather	The short-term variation in meteorological conditions, such as temperature, precipitation and wind.

Executive summary

Climate change presents a significant challenge for National Road Administrations (NRAs), both in dealing with its impacts on their network and in finding ways to reduce their greenhouse gas emissions. The DeTECToR (Decision-support Tools for Embedding Climate Change Thinking on Roads) project was commissioned through the Conference of European Directors of Roads (CEDR) Transnational Research Programme to help NRAs address these challenges. DeTECToR focuses on two key areas; developing the business case for climate change adaptation; and embedding consideration of climate change mitigation and adaptation into NRA operations and procurement. A decision-support tool and accompanying guidance was developed for both these areas. The risk assessment and cost-benefit analysis tool produced enables NRAs to identify the level of risk to different assets from relevant weather hazards and understand how this is likely to vary over time due to climate change. The procurement tool provides online guidance and case studies on the embedment of climate change in operations and procurement with a wiki functionality enabling NRAs to add and update the information.

This document is the guidance document accompanying the procurement tool. The guidance document is divided into two parts. Part A provides information, recommendations and examples of good practice on embedding climate change in NRA operations and procurement. The types of topics included are measuring carbon emissions, setting carbon reduction targets, including climate change risk assessments in operational processes and engaging the supply chain. Part B is the manual for the procurement tool and describes the tools functionality and how to modify the content and upload case studies.

About DeTECToR

DeTECToR (Decision-support Tools for Embedding Climate change Thinking on Roads) is part of the CEDR transnational research programme and was commissioned under the 2015 call for proposals 'Climate change: From desk to road'. The overall objective of DeTECToR is to help National Road Administrations (NRAs) put into practice the latest climate change research and good practice. The project produced decision-support tools and guidance documents that will enable NRAs to better integrate climate change considerations in economic and procurement decision making.

Specifically it produced:

- Summaries of relevant research projects, including recommendations and case studies describing how the findings and tools can be put into practice by NRAs;
- An economic decision-support tool that will enable cost-benefit analysis of different adaptation options for planning and asset management;
- A guidance document on embedding climate change research into economic decision making, which also provides guidelines and case studies on the use of the economic tool;
- An online procurement collaboration platform that will enable NRAs to share their approaches to including climate change in procurement and learn from each other's experiences; and
- A guidance document for embedding climate change mitigation and adaptation into NRA operations and procurement procedures, with guidelines and case studies on using the procurement tool.

Further information can be found on the project website https://detector.trl.co.uk/

This document

This document is the procurement guidance document which accompanies the procurement online collaboration platform. It is based on the literature review, stakeholder survey and NRA interviews carried out during the project.

The content is divided into two parts; guidance on embedding climate change in operations and procurement, and the manual on the DeTECToR procurement tool. The document is divided into the following sections:

Part A: Guidance on embedding climate change into operations and procurement

Section 1 gives the scope and context of the guidance.

Section 2 describes how to identity the sources and measure the quantities of carbon emissions.

Section 3 provides approaches in understanding climate change vulnerability and assessing risk.

Section 4 is on establishing carbon reduction and adaptation policy and targets.

Section 5 describes different procurement approaches and compares the benefits and disadvantages of these.

Section 6 is on assessing impact and engaging stakeholders in the processes.

Section 7 describes examples of implementation of procurement approaches.

Section 8 is on embedding in NRA operations.

Section 9 describes issues related to assurance and benchmarking.

Section 10 provides information on reviewing and improving/expanding the selected approach.

Part B: The DeTECToR procurement tool manual

Section 12 introduces the tool and provides the context.

Section 13 is an overview of the tool and its functionality.

Section 14 is a step-by-step guide to using the tool.

Section 15 describes worked examples of using the tool.

PART A: Guidance on embedding climate change into operations and procurement

CEDR
Conférence Européenne des Directeurs des Routes
Conference of European Directors of Roads

1 Guidance objectives and context

1.1 Why this guidance was produced

This guidance was produced to give readers an easily accessible reference on the subject of including climate change in NRA procurement processes and operations. The document draws on the literature reviewed and the knowledge generated in the DeTECToR project and presents it as a series of recommendations and case studies to the reader. It incorporates findings from previous CEDR projects and information from the three procurement pilot studies carried out as part of the project, in order to provide NRAs with an insight into the latest research and implementation in this area.

1.2 Guidance structure

The guidance document mirrors the information provided online in the procurement collaboration platform. As the online content develops over time, this guidance will remain a record of the initial content produced by the project. The sections are based on the steps or areas of action that an NRA needs to consider when embedding climate change mitigation and adaptation in their operations and procurement processes. These topic areas were agreed with the Programme Executive Board (PEB) and are shown in Figure 1.

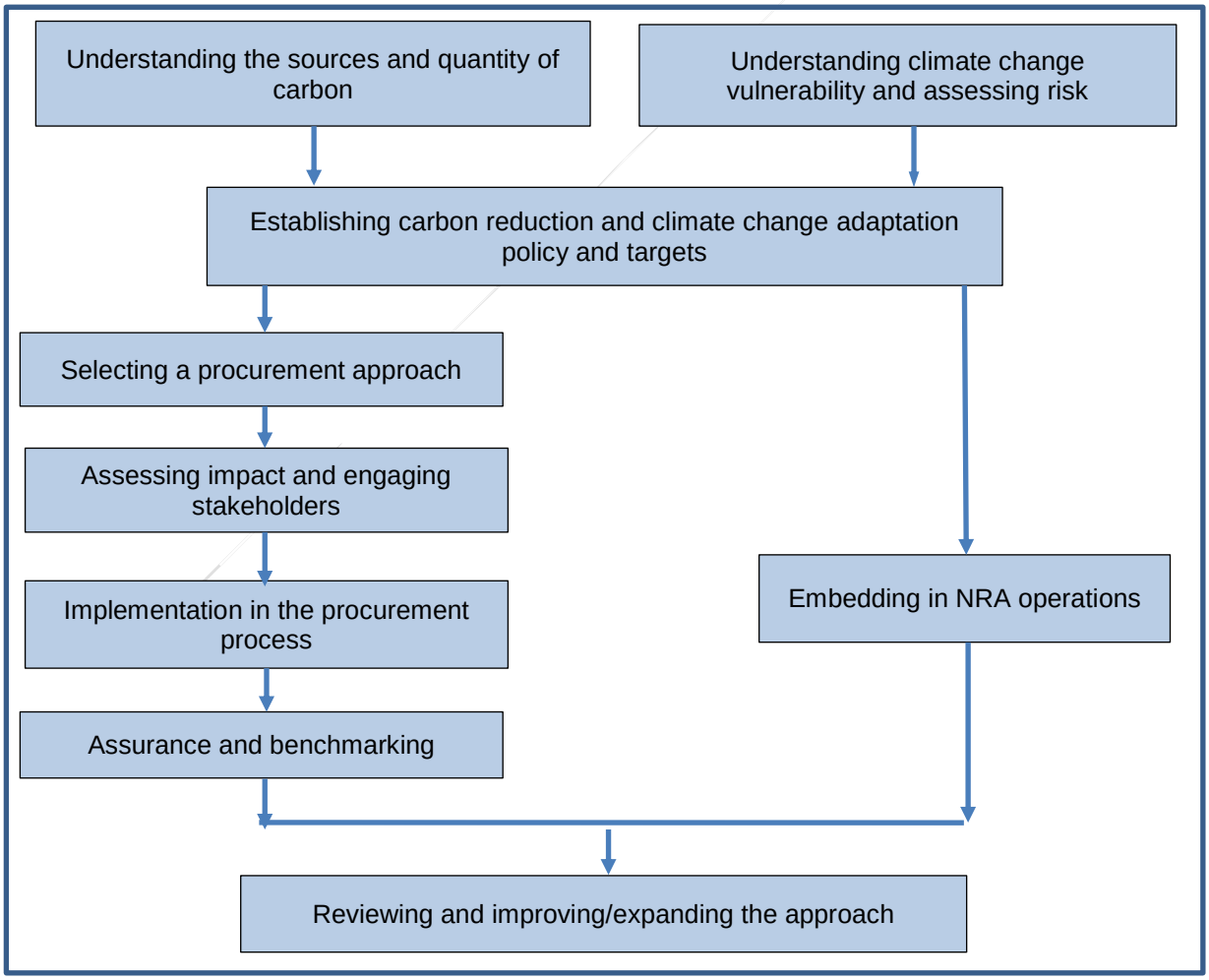


Figure 1. Guidance topic areas

The sections of the guidance are structured in a set way in order to make it easier for different readers to access the information they require.

Each section will start with some text which will serve to introduce the topic area and present questions and issues that a reader should consider when looking for guidance on the specific topic area.

There are then two types of highlight boxes that aim to draw out key information for the reader.

Following on from the general text the reader will be presented with a 'recommendations' box (see blue box below). The idea of these boxes is to present key recommendations to the reader for that specific topics area being discussed.

Recommendations:

- Example recommendation 1
  - Sub-point 1
- Example recommendation 2

For each topic area the reader will also be presented with an 'examples' box (see orange box below). These boxes will highlight relevant projects or case studies that the reader can refer to for additional information.

Example: Reference (Year). Text about the case study / reference.

Description of case study.

The idea behind having the different boxes is that it allows a reader to quickly draw out key information from the separate sections, therefore helping to make the guidance document a key resource they can continue to refer back to because it is easy and quick to navigate around it.

2 Understanding the sources and quantity of carbon emissions

2.1 Measuring carbon emissions

Road transport is responsible for 26 percent of total energy consumption which relates to about 24 percent of all CO_2 emissions (the main greenhouse gas (GHG)) in the EU, with passenger cars being responsible for more than half of these emissions (European Commission, 2010). Despite manufacturers reducing CO_2 emissions, increasing numbers of vehicles of the road means that emissions have been continuously growing by about two percent per year. Therefore, to fulfil the EU obligations and tackle climate change, CO_2 emissions from vehicles need to be reduced (European Commission, 2011). NRAs have a role to play in this by reducing their own carbon emissions and that of their supply chain, and also by influencing and supporting users of their network to reduce vehicle carbon emissions.

In order to reduce the carbon emissions associated with their activities NRAs need to identify the main sources and to be able to measure these. Recent European projects which provide approaches on measuring different types of carbon emissions associated with NRA activities include:

CEREAL (CO_2 Emission REduction IN roAd Lifecycles) - The project aimed at enhancing Europe wide carbon footprinting of road construction and pavement maintenance. A tool was developed for the prediction of CO_2 emissions in the construction and maintenance phase of roads called Carbon Road Map. Default data is available in the tool or report and part of the database is fed by LICCER. A benefit of this model structure is that it can be tailored to the local situation.

LICCER (Life Cycle Considerations in EIA of Road infrastructure) - The project developed a model including a framework and guidelines. This was based on existing tools and methodologies for Life Cycle Assessment (LCA) and GHG emissions of road infrastructure that can be used within an EIA process in the early stage of transport planning. The LICCER model includes site-dependent aspects of the planning such as the choice of a plain road, bridge or tunnel. The life-cycle model focuses on energy use and contribution to climate change. The LICCER model calculates the annual cumulative energy (consumption and greenhouse gas emissions) of the involved road corridor alternatives using default values. The model enables NRAs and other stakeholders to compare different road corridor alternatives in the decision-making process. The model is based on LCA methodology following the ISO 14040 standard. It was applied in two case studies in Sweden and Norway.

MIRAVEC (Modelling Infrastructure Influence on RoAd Vehicle Energy Consumption) - The project developed a spreadsheet tool based on simplified fuel consumption models that allowed the comparison of the effects of different infrastructure-related measures on fuel consumption and CO_2 emissions. The model requires data about the most widely available pavement and road layout parameters, and uses information about traffic flow and vehicles as background information. While the tool can be applied even with limited data, the strong influence of these background data found in the analysis may supersede the infrastructure effects in some cases. The MIRAVEC tool estimates the average vehicle speed from the road geometry, the level of rutting, ride quality, the level of traffic and the split of heavy to light vehicles. In addition, a simple method for estimating the effect of idle time due to traffic congestion has been developed and implemented. It further enables users to estimate

vehicle fuel consumption associated with a specific route and to explore the effects of various changes to the road infrastructure on the fuel consumption. This spreadsheet tool has been used to assess the potential benefits to be gained from making improvements to the infrastructure (i.e. the capacity for NRAs to provide energy reducing road infrastructure) by considering different scenarios and using statistical data available from national road networks.

The SULTAN Tool (SUstainabLe TrANsport) - The Illustrative Scenarios Tool has been developed as a high-level calculator (not an in-depth model) as part of the EC's on-going 'EU Transport GHG: Routes to 2050' study to help provide indicative estimates of the possible impacts of policy on transport in the EU (primarily energy use and GHG emissions, also costs, energy security, NOx and PM emissions) (Hill and Morris, 2012). The purpose of the tool is to allow the quick scoping of a wide range of transport policy options to get a feel for what scale of action might be required. It will also be used as part of the analysis for the final written technical outputs of the SULTAN project. The aim of the tool is to help transport and climate change stakeholders to develop Policy Scenarios, based on the assumptions on how policy will impact the future transport system, and then to allow them to quickly and easily view the GHG emissions that would result from the system under the Policy Scenario developed.

2.2 NRA carbon and LCA tools

Some NRAs have developed their own bespoke tools for measuring carbon emissions and in some cases other environmental impacts generated from their own activities and their supply chain's activities. These tools may be project/scheme based such as Sweden's Klimatkalkyl or per contract such as Highways England's carbon accounting tool which is used both on major projects and annually in maintenance contracts. These tools provide a consistent and transparent method of comparing the carbon emissions generated or likely to be generated from different designs, materials, transport approaches etc. The results may be used for monitoring/reporting only or to provide information for designers, but they are also starting to become part of the procurement process (see Section 7).

Example: DuboCalc, The Netherlands

DuboCalc is a software tool developed in-house by Rijkswaterstaat (RWS) which calculates the environmental impact of a construction design over its lifetime. The Life Cycle Analysis (LCA) methodology follows the ISO 14040 standard and calculates eleven environmental impacts including kg CO_{2e}. Weighting is applied to the different impacts, CO_2 has a 20% weighting. The tool is used to calculate the environmental impact for four project phases: construction; use; maintenance; and end of life based on design, materials, transport distances etc. The output is a single value referred to as the Environmental Cost Indicator (MKI) based on the analysis. A lower value indicates a design with a lower environmental impact. This enables designers to compare design and material options, but it is also used by RWS as part of their procurement process. Tenderers are required to submit the MKI as part of their proposal and demonstrate how they would achieve this. This value is used in the tender evaluation process (part of the MEAT criteria), and if their proposal is successful obtaining the promised MKI becomes a contract requirement. DuboCalc enables the NRA to objectively compare offers with which propose different sustainability measures such as using durable materials, sustainable logistics (limiting transport distances, limiting the number of traffic movements, working with transfer hub, alternative fuels, transport by water etc.), reducing energy consumption in the use phase and renewable energy generation within the project.

RWS passed the development and management of DuboCalc over to the software developer Cenosco and the engineering consultancy Royal Haskoning DHV. The latest version of the tool launched in 2017 - DuboCalc 5.0 can be found here https://www.dubocalc.nl/en/

The tool can be used for all types of construction and civil engineering work, not just road construction. Having a single national method of calculating the environmental impact of construction underpins the approach as suppliers understand the requirements and the environmental impact of different proposals can be compared.

Example: Highways England carbon tool

The Highways England carbon emissions calculation tool is based in Microsoft Excel (Excel), and all of the required data is collected in one Excel file. This file is used by all construction and maintenance contractors in their supply chain. When the data has been entered into the tool the contractor/supplier send it to the NRA where the carbon returns are then processed and interpreted. The tool is designed to make the data collection process as simple as possible. This includes:

- Keeping all carbon returns in one tool;
- Designating responsibility;
- Timescales;
- Pro forma to gather data;
- Improving awareness; and
- Enabling accuracy

The data required by the tool is split into categories largely based upon the Specification for Highways Works (the requirements for the work and materials to be used in constructing and maintaining the UK's national road network). These categories help the suppliers to see where materials, and the carbon emissions associated with them, are used across a construction or maintenance contract. It also provides a network wide overview which helps the NRA to see where they should focus their carbon management efforts.

Both the tool and the guidance document are available at:
https://www.gov.uk/government/publications/carbon-tool

Example: Klimatkalkyl, Sweden

Klimatkalkyl is a model developed by the Swedish Transport Administration (Traffikverket) for efficient and consistent calculation of the energy use and potential climate impact of transport infrastructure. The model can be used to make climate and energy calculations for individual investment projects, or for parts of investment projects, and as a tool for systematic and effective improvements in climate and energy efficiency of infrastructure. Developed in 2013, the tool uses information provided by the user about the specific materials and design being used in the project together with default data to calculate a CO_{2e} value for the project. Incorporated into the tool is a database containing emission factors for around forty construction materials. The user selects the type of component/material, and provides the quantities and transport distances; information already recorded for costing purposes. The tool is used at different stages in the project planning and procurement processes, firstly by the NRA to establish a baseline and set appropriate targets and then by the supplier to select a low carbon design for tender submission and establish the final carbon value. As the project progresses additional detail can be added providing a more accurate estimation. The tool was initially developed in Excel, but is now available online. It is reviewed and updated annually including adding data from new EPDs (verified by a third party). The tool builds on existing data (e.g. collected for costing) and is simple to use. Since February 2016 (version 5.0) it has been expanded to enable the calculation of the carbon associated with the maintenance of existing roads. Screenshots from the Klimatkalkyl user interface show the data input categories and output of results (Figures 2 and 3).

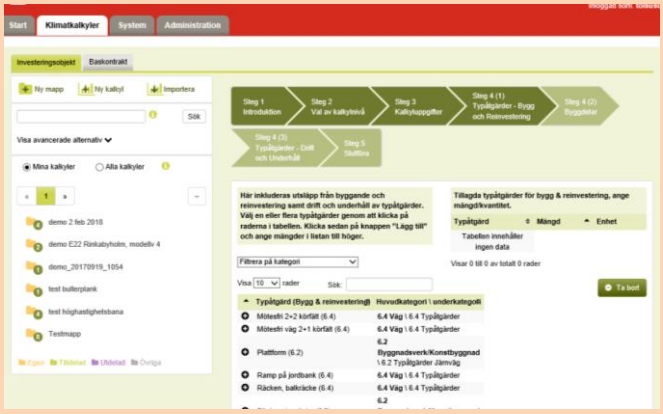


Figure 2. Klimatkalkyl user interface

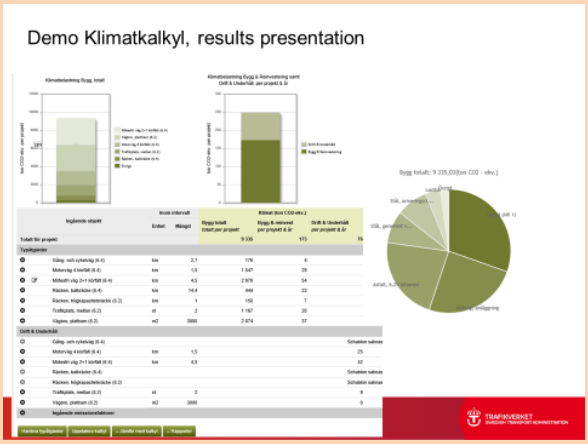
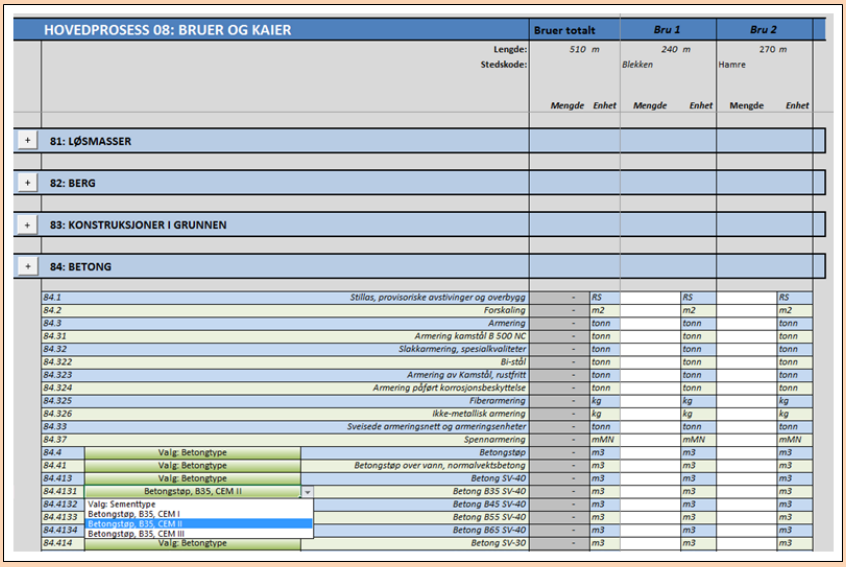


Figure 3. Klimatkalkyl results page

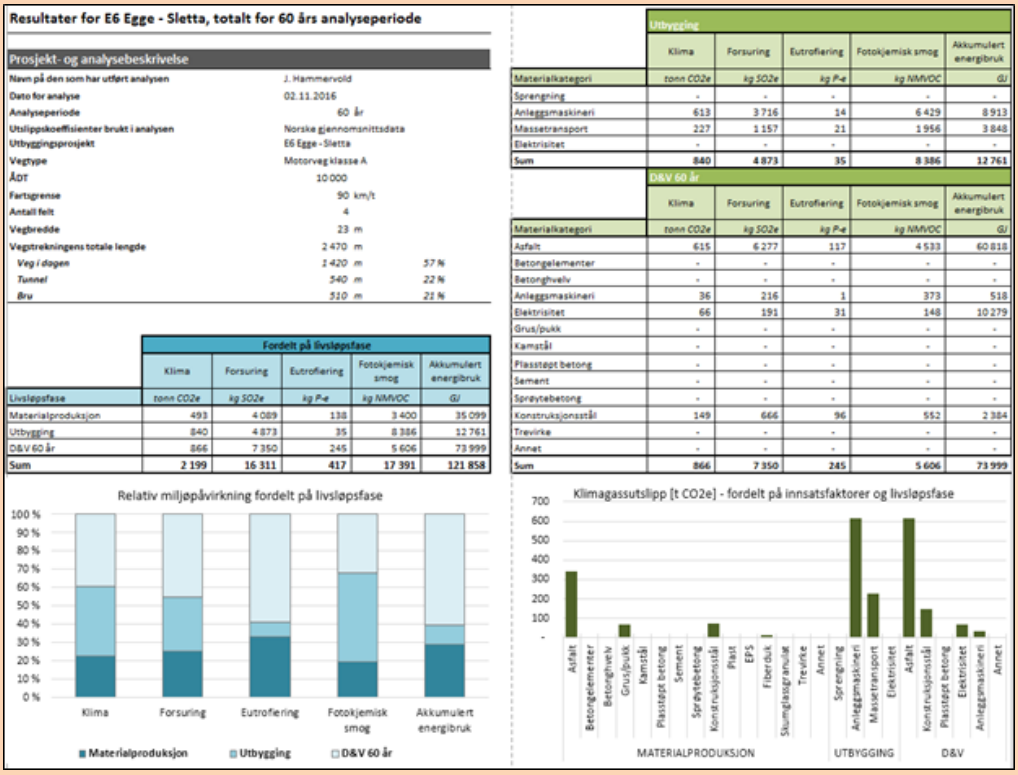
The Traffic Authority's guideline TDOK 2015: 0007 (Climate Calculation - Energy Conservation and Climate Impact in a Life Cycle Perspective) (link) provides information on when and how the tool should be used. The tool is available online (in Swedish) - http://webapp.trafikverket.se/klimatkalkyl/

Example: *VegLCA tool, Norway*

In 2015 the NPRA developed an Excel-based LCA tool called VegLCA-tool. The tool is used at the end of the road planning process (design and contract phase) when the amounts of materials required have been estimated. The purpose of VegLCA is the environmental optimisation regarding material choices, material quantities, transport distances, bridge and tunnel designs, construction equipment and technologies as well as regarding operation and maintenance. Figure 4 shows the input interface and result sheet of the VegLCA-tool. Default values for emission factors are included in the tool, but new values can be added.



HOVEDPROSESS 08: BRUER OG KAIER	Bruer totalt		Bru 1		Bru 2	
Lengde:	510 m		240 m		270 m	
Stedskode:			Blekken		Hamre	
	Mengde	Enhet	Mengde	Enhet	Mengde	Enhet
+ 81: LØSMASSER						
+ 82: BERG						
+ 83: KONSTRUKSJONER I GRUNNEN						
+ 84: BETONG						
84.1 Stillas, provisoriske avstivinger og overbygg	-	RS		RS		RS
84.2 Forskaling	-	m2		m2		m2
84.3 Armering	-	tonn		tonn		tonn
84.31 Armering kamstål B 500 NC	-	tonn		tonn		tonn
84.32 Slakkarmering, spesialkvaliteter	-	tonn		tonn		tonn
84.322 Bi-stål	-	tonn		tonn		tonn
84.323 Armering av Kamstål, rustfritt	-	tonn		tonn		tonn
84.324 Armering påført korrosjonsbeskyttelse	-	tonn		tonn		tonn
84.325 Fiberarmering	-	kg		kg		kg
84.326 Ikke-metallisk armering	-	kg		kg		kg
84.33 Sveisede armeringsnett og armeringsenheter	-	tonn		tonn		tonn
84.37 Spennarmering	-	mMN		mMN		mMN
84.4 Valg: Betongtype — Betongstøp	-	m3		m3		m3
84.41 Valg: Betongtype — Betongstøp over vann, normalvektsbetong	-	m3		m3		m3
84.413 Valg: Betongtype — Betong 5V-40	-	m3		m3		m3
84.4131 Betongstøp, B35, CEM II — Betong B35 5V-40	-	m3		m3		m3
84.4132 Valg: Sementtype — Betong B45 5V-40	-	m3		m3		m3
84.4133 Betongstøp, B35, CEM II — Betong B55 5V-40	-	m3		m3		m3
84.4134 Betongstøp, B35, CEM III — Betong B65 5V-40	-	m3		m3		m3
84.414 Valg: Betongtype — Betong 5V-30	-	m3		m3		m3



Resultater for E6 Egge - Sletta, totalt for 60 års analyseperiode

Prosjekt- og analysebeskrivelse

Navn på den som har utført analysen	J. Hammervold	
Dato for analyse	02.11.2016	
Analyseperiode	60 år	
Utslippskoeffisienter brukt i analysen	Norske gjennomsnittsdata	
Utbyggingsprosjekt	E6 Egge - Sletta	
Vegtype	Motorveg klasse A	
ÅDT	10 000	
Fartsgrense	90 km/t	
Antall felt	4	
Vegbredde	23 m	
Vegstrekningens totale lengde	2 470 m	
Veg i dagen	*1 420 m*	*57 %*
Tunnel	*540 m*	*22 %*
Bru	*510 m*	*21 %*

Fordelt på livsløpsfase	Klima	Forsuring	Eutrofiering	Fotokjemisk smog	Akkumulert energibruk
Livsløpsfase	tonn CO2e	kg SO2e	kg P-e	kg NMVOC	GJ
Materialproduksjon	493	4 089	138	3 400	35 099
Utbygging	840	4 873	35	8 386	12 761
D&V 60 år	866	7 350	245	5 606	73 999
Sum	2 199	16 311	417	17 391	121 858

Relativ miljøpåvirkning fordelt på livsløpsfase

Utbygging	Klima	Forsuring	Eutrofiering	Fotokjemisk smog	Akkumulert energibruk
Materialkategori	tonn CO2e	kg SO2e	kg P-e	kg NMVOC	GJ
Sprengning	-	-	-	-	-
Anleggsmaskineri	613	3 716	14	6 429	8 913
Massetransport	227	1 157	21	1 956	3 848
Elektrisitet	-	-	-	-	-
Sum	840	4 873	35	8 386	12 761

D&V 60 år	Klima	Forsuring	Eutrofiering	Fotokjemisk smog	Akkumulert energibruk
Materialkategori	tonn CO2e	kg SO2e	kg P-e	kg NMVOC	GJ
Asfalt	615	6 277	117	4 533	60 818
Betongelementer	-	-	-	-	-
Betonghvelv	-	-	-	-	-
Anleggsmaskineri	36	216	1	373	518
Elektrisitet	66	191	31	148	10 279
Grus/pukk	-	-	-	-	-
Kamstål	-	-	-	-	-
Plasstøpt betong	-	-	-	-	-
Sement	-	-	-	-	-
Sprøytebetong	-	-	-	-	-
Konstruksjonsstål	149	666	96	552	2 384
Trevirke	-	-	-	-	-
Annet	-	-	-	-	-
Sum	866	7 350	245	5 606	73 999

Klimagassutslipp [t CO2e] - fordelt på innsatsfaktorer og livsløpsfase

Figure 4. Screenshots from VegLCA (in Norwegian)

2.3 Emission factor data sources

The carbon emission factors that are used in LCA tools are normally sourced from Environmental Product Declarations (EPDs). An EPD is a comprehensive, internationally-harmonised report that documents the ways in which a product, throughout its lifecycle, affects the environment. An EPD tells the lifecycle story of a product in a single, written report, focusing on information about a product's environmental impact, such as global warming, ozone depletion, water pollution, ozone creation, and greenhouse gas emissions. An EPD can also include other impacts that are of particular interest to the discloser, such as human toxicity, risk and corporate social responsibility.

EPDs do not rank products, and the existence of an EPD for a product does not indicate that environmental performance criteria have been met. EPDs are a disclosure tool that helps purchasers better understand a product's sustainable qualities and environmental repercussions so they can make more informed product selections. EPDs can be developed after a product lifecycle assessment (LCA) is conducted, and are based on applicable product category rules (PCRs). The standard procedures for creating an EPD are set out in ISO 14025.

Example: National EPD database, the Netherlands

The Netherlands has a national database of EPDs which provides an easily accessible, consistent data source for carrying out LCA. The Dutch EPD database is managed by an independent organisation (SBK) and was produced following a Government coordinated project to establish one LCA calculation methodology. There are three types of information categorises in the database:

- Brand data verified by an independent third party according to the SBK verification protocol
- Generic data for non-branded materials, verified by an independent third party according to the SBK verification protocol
- Generic data for non-branded materials which have not been verified.

EPDs for new materials can be submitted to SBK who manage the database via an online procedure. They will approve the submission. The EPD verification protocol can be found here http://www.milieudatabase.nl/imgcms/SBK_Verification_Protocol_version_2_0_TIC_versie.pdf

Example: EPD generator tools, Norway

As part of the procurement approach being piloted in the KraKK project Norwegian NRA suppliers need to provide EPDs for products made from certain materials (concrete, steel and asphalt) in order to obtain a bonus. The EPDs can be certified EPDs from product manufacturers or can be calculated themselves using an EPD tool certified by EPD Norway. EPD Norway ensures that the development of EPDs is performed to the requirements of ISO 14025 and related standards. The EPD tool requires information on the raw materials, energy use and transport. The Norwegian NRA will employ a third party verifier to carry out random checks on the supplier generated EPDs.

2.4 Major sources of carbon

The majority of carbon produced over a road's lifecycle is produced by the (currently) predominately fossil-fuelled vehicles that use the road. However, the carbon associated with the construction and maintenance of the infrastructure is not insignificant and NRAs are able to exert greater influence over this. A number of NRAs have used the results of LCA to identify the main sources of carbon resulting from their different activities, in order to focus their efforts on these. For example the Dutch NRA is piloting a procurement approach which targets materials with high embodied carbon (concrete, asphalt and steel reinforcement) and encourages the use of alternatively fuelled maintenance vehicles.

Example: Sweden's carbon measurement results

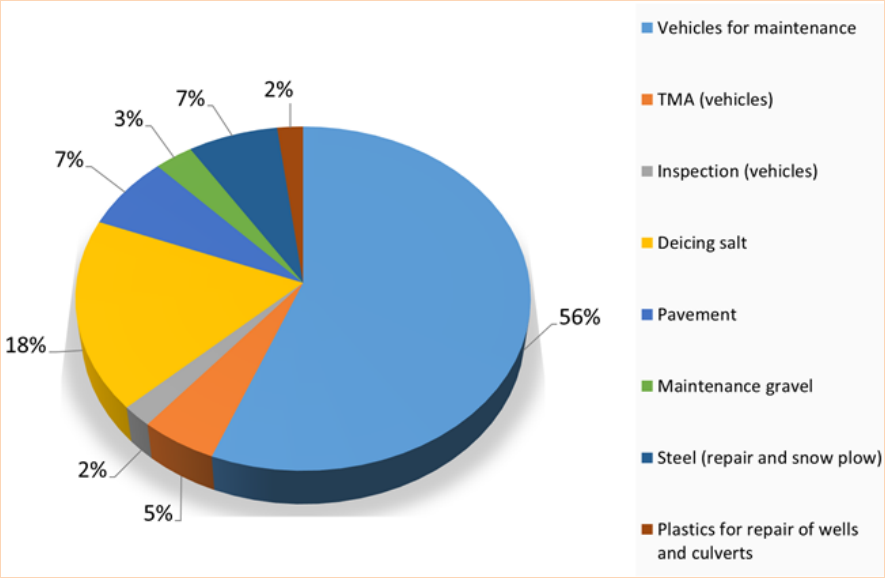


Figure 5. Sources of GHG in road maintenance, *Klimatkalkyl baskontrakt väg, WSP*

Major contributors of GHG emissions in road maintenance are:

- Vehicle fuel
- De-icing salt
- Pavement
- Repair of railing and use in snowploughs (steel)

Sources GHG emissions from infrastructure projects (both road and rail) include:

- Concrete/Cement
- Machineries and trucks (fuel)
- Reinforcement steel
- Construction steel
- Asphalt

Road maintenance contributes 0.11 million tonnes of CO_{2e} per year.

Example: Norway's carbon measurement results

Approximately 2.2 million tonnes per year of CO_2 comes direct from the Norwegian public road infrastructure. This is not including the production and operation of cars nor the production and extraction of fuel and oil. Investments in new road construction dominate the infrastructure's carbon footprint.

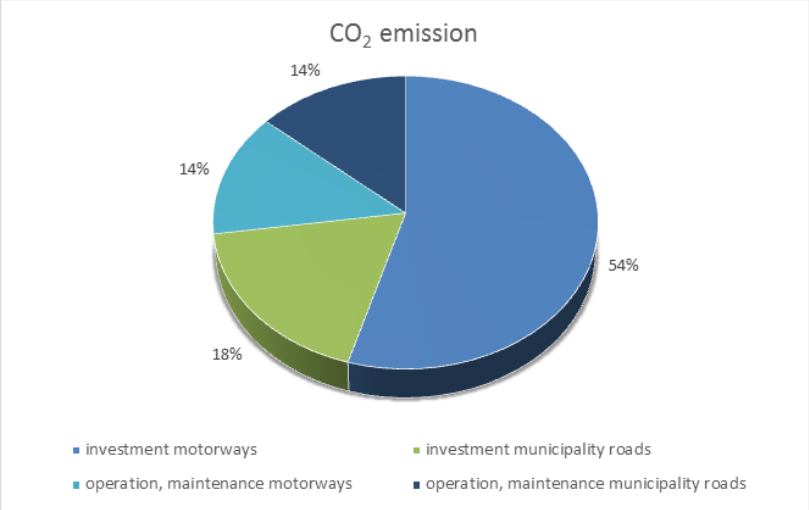


Figure 6. Norwegian road infrastructure sources of carbon emissions

Example: The Netherlands's carbon measurement results

The Dutch NRA (RWS) have calculated their annual carbon footprint (818 kTonnes) and identified the key material/activities which contribute to this. It is focusing its efforts on these areas namely asphalt, concrete and groundworks (including dredging).

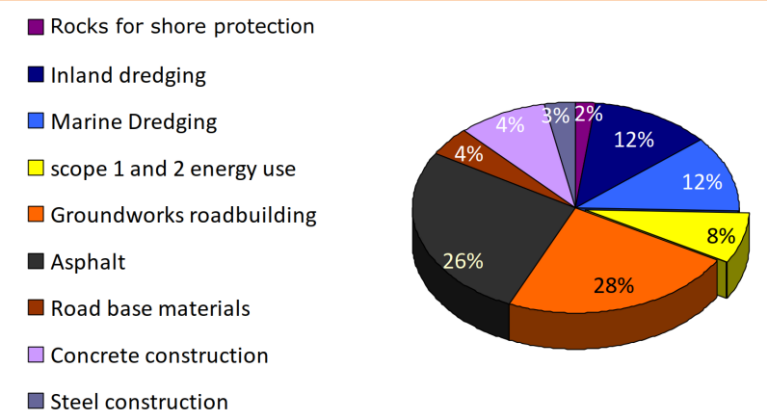


Figure 7. RWS annual carbon footprint (source: RWS)

Recommendations:

- NRAs should seek to understand the major sources of carbon emissions resulting from the activities of their organisation and their suppliers.
- Measurement needs to be carried out at several different levels e.g. organisational and project level. At an organisation level it provides information on progress towards carbon reduction targets and helps to identify the activities which generate the most emissions. At a project level it enables the influence of different materials, designs, transport methods and actions to reduce carbon to be assessed. It also allows targets to be set a project level and benchmarking between projects.
- There are various LCAs tools available, but many NRAs choose to develop a bespoke tool tailored to for a specific use. Any LCA tool used should follow the ISO 14040 standard.
- The sources of data used in LCA tools needs to be robust and transparent, for example using verified EPDs. If the EPD is generated by a supplier, it needs to be independently verified.
- The use of EPDs is not confined to the road industry, therefore NRAs should participate in national and European cross-sector initiatives to develop databases, standardise generation methodologies and encourage use of EPDs.

3 Understanding climate change vulnerability and assessing risk

Road infrastructure, vehicles and operations are constantly exposed to weather hazards, and their construction and operation is influenced by the climate in which they are located. Climate change brings a new element to this, as road operators seek to better understand the influence of different weather variables on different types of infrastructure and how changes in climate could influence these.

3.1 Climate variables

The main climate variables are:

Temperature: Extremely high temperature poses a number of threats to infrastructure, such as degradation of road surfaces or stability problems of bridges and other supporting structures due to thermal expansion. Moreover, prolonged episodes of very high temperature cause health stress on road workers and travellers delayed in traffic.

Extremely low temperature is also a hazard, freezing temperatures can damage pavements and the threat of icing requires expensive winter service action. In addition, bridges and other structures suffer from stability problems due to the negative thermal expansion. Low temperature is a health issue as well. It should be kept in mind that days with freeze-thaw-cycles and their immense expansion-contraction stress are particularly hazardous for road surfaces. A helpful extension of the freeze-thaw-cycle definition is to attribute such days to conditions when the minimum is below -2°C and the maximum is above +2°C (Matulla et al., 2014).

Climate projections show an increase of heat stress but also an increase in variability (i) in the climate projection of any individual climate model and (ii) across an ensemble of climate projections by several models. This means that the temperature range to which the infrastructure is exposed increases. As a derived consequence, it should be added, a future climate will not only exhibit fast increase in high temperature threats but also a rather slow decay of the low temperature threats. Furthermore, areas which previously remained almost entirely in a subfreezing temperature range during the winter months will face an increase in the freezing-thawing cycles as temperatures increase.

Precipitation: Extremely high amounts of rainfall pose a severe threat to transport infrastructure as it causes excessive runoff with ensuing flooding and also can cause inundation from nearby rivers. It also indirectly can result in landslides which lead to traffic disruptions and high repair costs. Large amounts of snow leads to hazardous usage conditions of the infrastructure and is another cause for traffic disruptions. Moreover, they necessitate the deployment of equipment to deal with winter conditions.

Droughts, on the other hand are a hazard to ecosystems surrounding the transportation infrastructure and can inflict fire or contribute to the degradation of landscape surfaces which, in turn, exacerbates runoff problems, should they be followed by heavy precipitation. Large changes in moisture content can also cause subsidence and heave.

Climate projections point towards a climate shift in which summer precipitation decreases in large areas and winter precipitation increases. The picture is complex, though, due to the fact that numerous processes in the earth-atmosphere system contribute to precipitation or

drought. This includes a superimposed large-scale effect which causes areas around the Mediterranean Sea to become generally drier. Yet, the climate projections also point towards an increase in variability. Consequently, the probability of extreme precipitation occurring is projected to be of similar, if not higher magnitude.

Wind: Large-scale motion of the atmosphere in combination with topographical features in the landscape can cause high-wind threats to transportation infrastructure. This encompasses storm-related damage to infrastructure and the disruption of traffic, e.g., by uprooted trees. High winds can also cause reduced visibility. Climate projections point at changes in the global wind systems, like displacement of storm tracks. The average wind velocity however is subject to relatively small deviation from current climate conditions. It should be added that local wind extremes are not fully covered by climate projections since the complex interactions with the atmosphere and highly detailed orography are not entirely included in the modelled physics and since the model's resolutions are not high enough to fully address local and hazardous wind extremes.

Another impact of climate change is **sea level rise**. This is a hazard for coastal infrastructure particularly in areas of low lying land. Related to this is the impact of storm surge, where a higher sea level combined with a storm can cause severe inundation and damage to coastal roads. However, it should be mention that sea-level rise is a secondary event caused by the climate change, since the sea-level rise is caused by increasing temperature.

3.2 Assessing climate risk

At first glance, a broad range of research projects include the topic of assessing climate risk and roads are often mentioned to be part of the projects' context. However, many research projects are high level and abstract in scale, evaluating climate related risks in terms of macroeconomic parameters and macrosocial challenges. As NRAs are responsible for the development and operation of national road networks or sub-nets, risk assessment approaches need to refer concretely to a particular network segment/road section or even to a specific road element or building to support NRAs' decision-making processes. The results of risk assessments that are part of coarse scale research projects are often of limited value for NRAs since they do not correspond to the level of detail required in the NRAs' actual decision-making. With a closer look it becomes apparent that only a very few research projects do actually refer to questions of risk assessment in a level of detail that matches the perspective, concerns and information needs of NRAs. In particular, for the assessment of climate related risks to road infrastructure, concrete approaches potentially suitable for NRAs' scopes of responsibility are rare.

The research projects display differences regarding how climate change is reflected. Some projects focus more or less 'only' on extreme weather events (heavy rain, hot spells etc.). Other projects take on a broader view and therefore look at the change of the actual climate parameters. This allows them to reflect on not only extreme events (which are expected to increase in size and frequency with climate change) but also enables them to reflect on the gradual parameter changes (such as changes in numbers of 'summer days' or of freeze-thaw-cycles etc.). This broader, more comprehensive is likely to better fit the NRAs' need for information to inform effective asset management.

Research projects often focus on qualitative assessment methods as they experienced problems in the availability of comprehensive data. This is undoubtedly an issue, however without attempting to identify or assess relevant data it is not possible to provide the level of detailed information NRAs need. The few approaches that do include quantitative evaluation

steps differ regarding whether and how climate projections are included in the risk assessment. All projects use historical weather data; some projects have also used climate projections to reflect future climate scenarios. This makes assessment approaches more meaningful.

The research projects differ regarding the size of investigation area and display different levels of detail with regard to the examined (road) infrastructure (network/subnets/road sections; road as a whole versus differentiation according to road elements; focus on specific technical components, e.g. drainage).

An important methodical basis is provided by the research project **RIMAROCC** (Risk Management for Roads in a Changing Climate).The main focus of the project was translating the steps of a common risk management process (e.g. ISO 31000) into the explicit context of climate change induced risks to roads (see Figure 8).This also includes conceptual considerations for risk assessment. Results have been refined with respect to practical applicability in the follow-up projects for ROADAPT and RIVA, which built upon the RIMAROCC methodology.

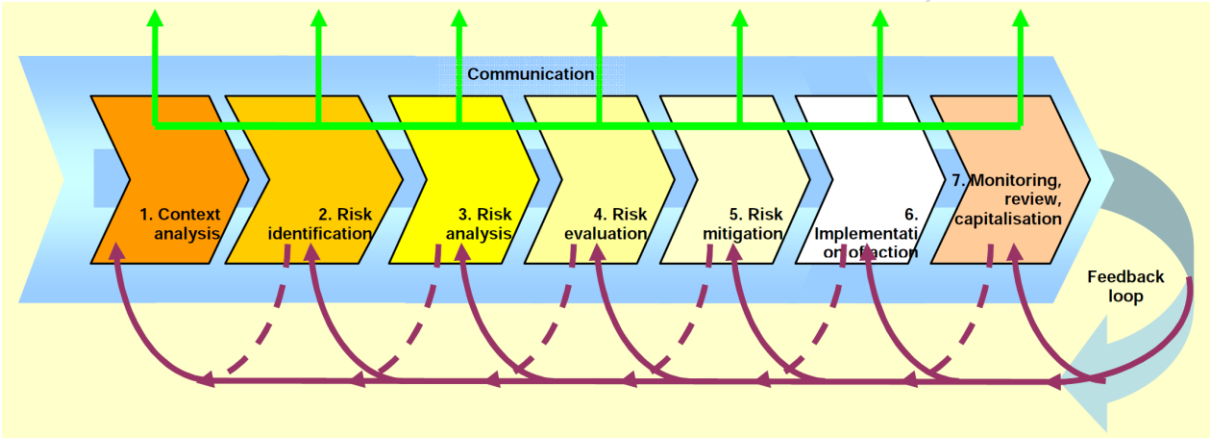


Figure 8: risk management process
Source: Bles, T. et al., 2010. Risk Management for Roads in a Changing Climate - A Guidebook to the RIMAROCC Method, ERA-NET ROAD

Table 1 describes in detail the key steps of Figure 8.

Table 1: sub-steps of the risk management process
Source: Bles, T. et al., 2010. Risk Management for Roads in a Changing Climate - A Guidebook to the RIMAROCC Method, ERA-NET ROAD

Key steps	Sub-steps
1. Context analysis	1.1 Establish a general context 1.2 Establish a specific context for a particular scale of analysis 1.3 Establish risk criteria and indicators adapted to each particular scale of analysis
2. Risk identification	2.1 Identify risk sources 2.2 Identify vulnerabilities 2.3 Identify possible consequences
3. Risk analysis	3.1 Establish risk chronology and scenarios 3.2 Determine the impact of risk

	3.3 Evaluate occurrences 3.4 Provide a risk overview
4. Risk evaluation	4.1 Evaluate quantitative aspects with appropriate analysis (CBA or others) 4.2 Compare climate risk to other kinds of risk 4.3 Determine which risks are acceptable
5. Risk mitigation	5.1 Identify options 5.2 Appraise options 5.3 Negotiation with funding agencies 5.4 Formulate an action plan
6. Implementation of action plans	6.1 Develop an action plan on each level of responsibility 6.2 Implement adaptation action plans
7. Monitor, review and capitalise	7.1 Regular monitoring and review 7.2 Re-plan in the event of new data or a delay in implementation 7.3 Capitalisation on return of experience of both climatic events and progress of implementation

The direct successor of the RIMAROCC project was the project named **ROADAPT** (Roads of today, adapted for tomorrow). The project outcomes per se can be understood as a further concretisation of RIMAROCC, particularly with regard to the guidelines A (use of climate data), C (vulnerability assessment) and E (adaptation strategies). Within this project a quickscan approach was developed (guideline B). The approach intends several workshops. However, it is questionable whether the workshop based approach would be applicable for the handling of large complex networks, such as national road networks or comprehensive subnets. Guideline D of the ROADAPT-project proposes an approach for socioeconomic-impact assessment, however, only for the assessment of potential loss of time for evaluation of the various climate change related threats. As part of the guideline E a database for several adaption actions depending on the risk and the asset was developed in the ROADAPT-project.

The **RIVA**-project (Risk analysis of key transport corridors of the German motorway network in the context of climate change) focuses on risk assessment for the German motorway network and aimed to develop a methodology as well as a pilot tool for assessing risks for current and future time periods for a complex road network. Attributes of climate and infrastructure are incorporated into a hierarchic structured indicator model. Accordingly, the risk assessment model takes into account climate events, vulnerability of risk elements, characteristics of potential effects and criticality of infrastructure as the four dimensions of attributes. The project defined the ‘damage pattern category’ as unit for investigation – see Table 2. This copes with the fact that climate induced damages often relate to more than one climate event/parameter (combination or sequence). At the same time this allows for aggregation and structuring of the range of various potential effects on infrastructure elements to a reasonable and workable set of investigation units. The method provides evaluation for the potential exposure to hazards (sphere of cause), for the potential of effects (sphere of effect) and for the overall risk potential as a function of cause and effect.

The inclusion of characteristics of the potential effects, as well as of criticality, allows for the display of different potentials of effect; this enables the validation of risks from the economic perspective. The modular structure of the tool allows for integration of further/changed damage pattern categories and for expansion/change of parameter sets; therefore, it is able to include future findings.

Within the RIVA-project a pilot tool was set up and trialled on parts of the German trunk road network.

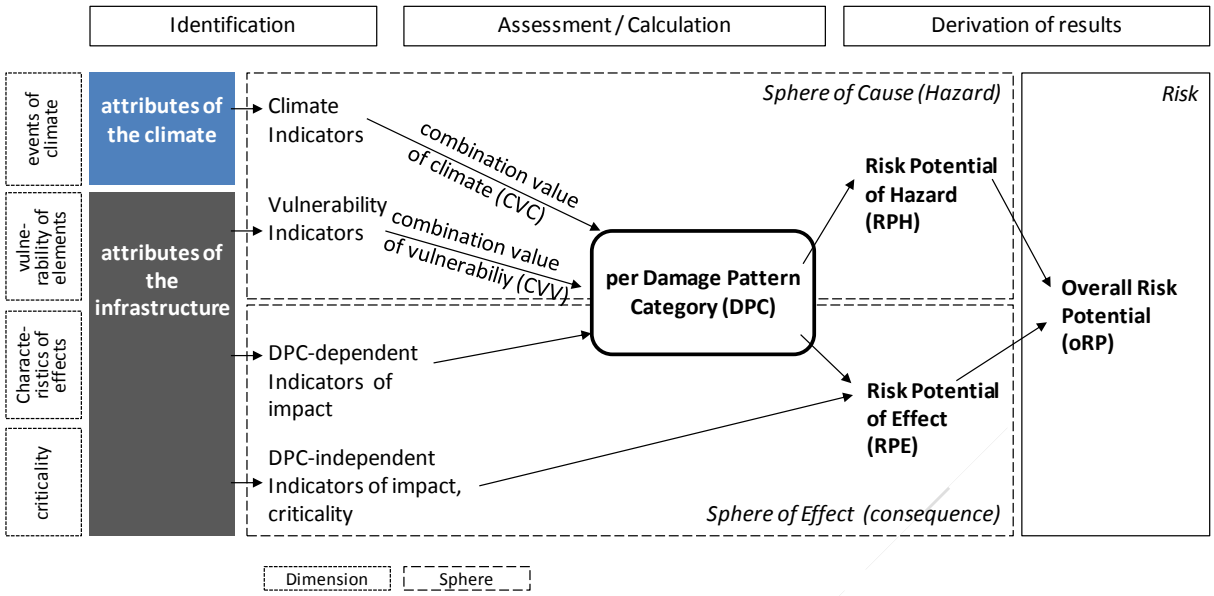


Figure 9: Basic structure of the hierarchical RIVA indicator model
Source: Korn, M. et al., 2017. Final report, Risk analysis of key transport corridors of the German motorway network in the context of climate change

Table 2: overview of damage pattern categories
Source: Korn, M. et al., 2017. Final report, Risk analysis of key transport corridors of the German motorway network in the context of climate change

DPC -nr.	risk element	description of the damage pattern categories
01a	Bridges	heat-related damages and restrictions at bridges
01b	Bridges	frost-related damages and restrictions at bridges
01c	Bridges	damages and restrictions at bridges caused by freeze-thaw-cycles
01d	Bridges	damages and restrictions at bridges caused by high water
01e	Bridges	damages and restrictions at bridges caused by storm
02a	Culverts	damages and restrictions at culverts high water
03a	tunnel	rainfall-related damages and restrictions at tunnels
03b	tunnel	heat-related damages and restrictions at tunnels (entrance)
03c	tunnel	frost-related damages and restrictions at tunnels (entrance)
03d	trough structure	rainfall-related damages and restrictions at trough structure
03e	trough structure	heat-related damages and restrictions at trough structure
03f	trough structure	frost-related damages and restrictions at trough structure
04a	retaining structures, slope reinforcement	heat-related damages and restrictions at retaining structures, slope reinforcement
04b	retaining structures, slope reinforcement	frost-related damages and restrictions at retaining structures, slope reinforcement
04c	retaining structures, slope reinforcement	rainfall-related damages and restrictions at retaining structures, slope reinforcement
05a	slopes	damages and restrictions caused by landslide events

06a	asphalt road surface	heat-related damages and restrictions on the asphalt road surface
06b	asphalt road surface	frost-related damages and restrictions on the asphalt road surface
06c	asphalt road surface	restrictions on asphalt road surfaces caused by high water
06d	asphalt road surface	restrictions on asphalt road surfaces caused by insufficient water runoff (aquaplaning)
06e	asphalt road surface	restrictions on asphalt road surfaces caused by clear ice
07a	concrete road surface	heat-related damages and restrictions on the concrete road surface
07b	concrete road surface	frost-related damages and restrictions on the concrete road surface
07c	concrete road surface	restrictions on concrete road surfaces caused by high water
07d	concrete road surface	restrictions on concrete road surfaces caused by insufficient water runoff (aquaplaning)
07e	concrete road surface	restrictions concrete road surfaces caused by clear ice
08a	road equipment.	damages and restrictions at road equipment caused by storm
09a	drainage	damages and restrictions caused by failure to operate of the drainage through intense rainfall (aquaplaning)
09b	drainage	damages and restrictions caused by failure to operate of the drainage through snowfall (aquaplaning)
10a	rainwater basin	damages and restrictions caused by failure to operate of the rainwater basin through intense rainfall
10b	rainwater basin	damages and restrictions caused by failure to operate of the rainwater basin at dry periods
10c	rainwater basin	damages and restrictions caused by failure to operate of the rainwater basin at snow and freeze events
11a	road user	health risks the road users caused by heat
11b	road user	reduced visibility of road users as a result of intense rainfall
11c	road user	hazards to the road users caused by storm

3.3 Data sources

Robust risk assessment requires various types of asset, climate and cost data. NRAs use different databases for the management of their road infrastructure containing information on the location, characteristics and condition of infrastructure and details of traffic. The specific contents and quality of those databases vary from NRA to NRA, but there are some general similarities. Information from surveys and inspections are uploaded into these databases and used in planning maintenance, budgeting and reporting.

An appropriate source for regional climate projection data is provided by a European project called CORDEX. CORDEX is an unprecedented initiative to cover continent-wide areas concerning climate model data. This encompasses re-simulations of the current climate and climate projections with regional climate models. CORDEX has the advantage to provide data on a unified grid that covers Europe. The ensemble of climate projections varies in size with respect to the greenhouse gas scenario used: For a “business as usual” scenario leading to a strong future increase of greenhouse gas concentrations nearly 40 model runs have been carried out. For a “strong impact containment” scenario leading to a future with a global temperature rise below 2°C above pre-industrial conditions the ensemble contains on the order of 15 model runs. The CORDEX grid is available in 50km or 10km resolution. CORDEX data will be available by the end of 2017 for free. It encompasses projections of a

wealth of surface climate parameters, such as temperature, humidity and wind as well as projections of derived climate indicators.

Some countries have developed their own climate projection studies and have established databases which may be used to complement the CORDEX data.

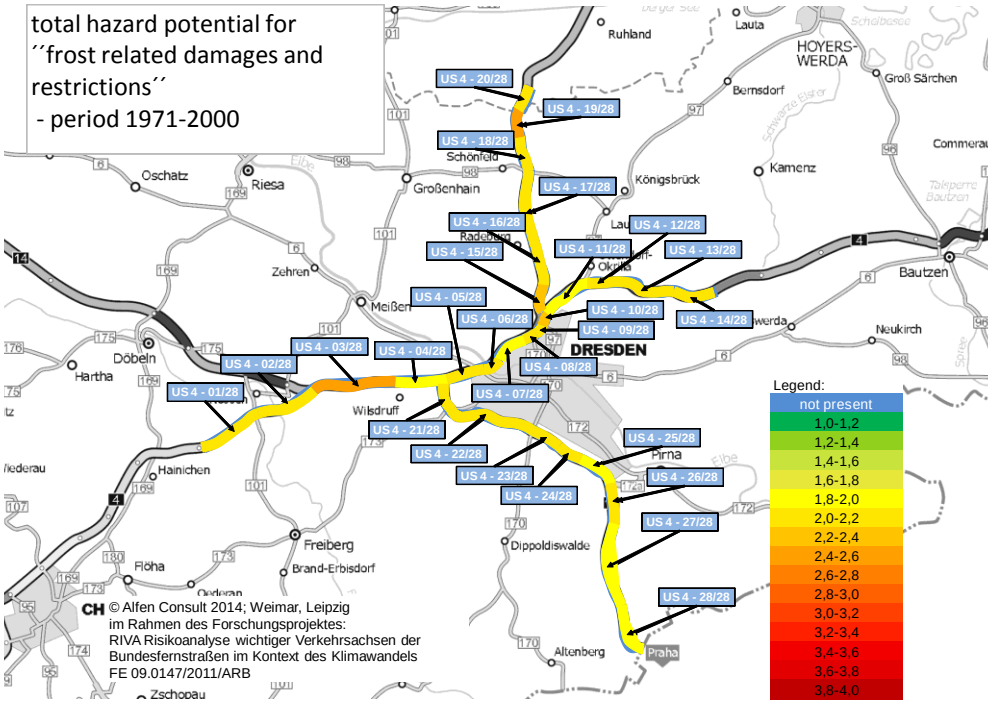
Recommendations:

- The collection and management of high quality asset data underpins robust climate change risk assessment (as well as effective asset management in general).
- In addition to asset data, NRAs should source other types of data such as geology, topography and land-use from third parties in order to fully understand the risks to their network.
- It is preferable to use an ensemble of climate model projections to obtain a higher degree of insight into the bandwidth of expected changes and hazardous impacts,
- Adaptation to climate conditions under the “business as usual” future scenario as well as those conditions according to the “less than 2°C global temperature rise” scenario need to be taken into account.
- It should be kept in mind that some climate projections provide a high degree of congruence, e.g., average conditions of temperature, whereas others exhibit a higher degree of variability, e.g., projections of average precipitation and wind conditions as well as extremes of any atmospheric parameter.

3.4 Case studies

In the context of climate change induced risk or vulnerability assessment results for testing / pilot region investigated during several research projects are available.

ROADAPT	
Country:	The products and guidelines have been used in three case studies, namely the Öresund region (Falemo et al., 2014), the Rotterdam Ruhr corridor (Bles et al., 2014) and the A24 in Portugal (Ennesser, 2014).
Specific characteristics of the area:	Öresund region: The study area covered approximately 50 km of the TEN-T road E6 Malmö – Landskrona and the TEN-T roads E55 Copenhagen - Helsingör and E20 Köge. Rotterdam Ruhr corridor: 1. Rotterdam – Utrecht – Arnhem (A15-A20-A12); 2. Rotterdam – Tiel – Nijmegen – Venlo (A15-A73); 3. Rotterdam – Breda – Eindhoven – Venlo (A15-A16-A58-A67) A24 Portugal: The A24 motorway linking the Portuguese cities of Viseu and Chaves is divided into 7 main sections. This 157 km motorway section, included in the Trans-European road network, opens up the north of Portugal and provides ready access to Spain from the centre of the country. A number of large viaducts, long sections of steep grades and other engineering features were needed to fit the motorway into the mountainous topography of Northern Portugal.
Investigated elements/risks:	The case studies included different sets of threats for the Oresund region: • Flooding of road surface (no traffic is possible) • Erosion of road embankments and foundations • Landslips, avalanches, ground subsidence or collapse • Loss or road structure integrity • Loss of pavement integrity • Loss of driving ability due to extreme weather events • Reduced ability for maintenance • Susceptibility to wildfires that threaten transport infrastructure • Damage to signs, lightning, lighting fixtures, canopies, pylons, noise barriers etc. because of strong winds
Results:	The Quickscan approach was tested in the course of all case studies. Additionally, within the Öresund case study a vulnerability assessment of drainage was conducted by help of the blue spot model developed in SWAMP. For the Öresund region also a socio-economic assessment was undertaken for a traffic event in the form of closure of the motorway E20 South of Copenhagen to estimate the potential time loss by road network users during the event duration.

RIVA	
Country:	Germany
Specific characteristics of the area:	Example assessment of nine motorway routes comprising 1 200 kilometres in total, assessment based on 11 specifically projected climatic regions
Investigated elements/risks:	- Bridges, tunnels, trough structures, geotechnics, Pavements (asphalt, concrete) road user) - four examination periods (1971-2000, 2011-2040, 2041-2070 and 2071-2100)
Results:	The case studies show that heat-related risks in particular will face a marked increase in the future. The results also indicate that condition, age and traffic volume as well as type of construction are the drivers for vulnerability of infrastructure elements. Furthermore, the inclusion of characteristics of potential effects as well as of criticality allow for display of different potentials of effect and therefore also for a validation of risks from the economic perspective.  graphic rendition – total hazard potential frost related damages and restrictions – period 1971-2000, for testing region no. 4 (A4/A13/A17 around Dresden)

There are several NRAs that have also carried out different forms/levels of risk assessment on their network or organisation. Similarly to the research projects, these are predominantly indicator based assessments.

Example: Risk assessment at a network level, Norway

The Norwegian NRA (NPRA) has developed a tool for climate change risk assessment called VegROS. It uses a semi-qualitative indicator method and includes a set of spreadsheets, algorithms, and guidance rules on how to assess vulnerability of assets including climate change. Version 1 was released in 2014; version 3 is due to be launched in 2019. The assessment is carried out by a local team using their knowledge of the network together with relevant maps and data. It includes climate data up to 2050. For each section of road the threat (probability and consequence), value and adaptive capacity are scored and then combined using the equation below to give an overall risk score from 1-3. Risk is categorised into low (yellow), medium (orange) and high (red) and mapped onto the network. A risk assessment if performed annually on all national roads using VegROS.

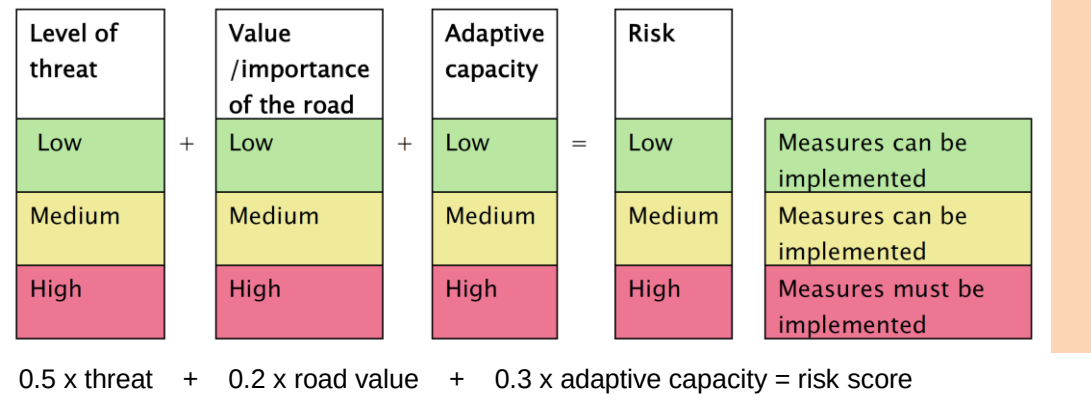


Figure 10. Calculation of the VegROS risk score

Example: Risk assessment at a project level, the Netherlands

The Dutch infrastructure owner Rijkswaterstaat carried out a project on resilient and adaptive road infrastructure design. They applied the risk assessment methodology developed in the CEDR funded ROADAPT research project and the dynamic pathways approach to a planned road project in order to identify actions to improve its resilience and any wider lessons for the Dutch road network. The road project was the widening and major maintenance and refurbishment of a 50km section of the A58 highway. Rijkswaterstaat, the consultants Deltares and local stakeholders identified potential weather hazards and assessed the level of risk of these. The top five risks were assessed in more detail and potential solutions assessed for their effectiveness. The most viable solutions were plotted as dynamic pathways. The project concluded both approaches were useful in designing more resilience infrastructure and highlighted the need for involving different local stakeholders and taking an area-based approach. The joint Rijkswaterstaat and FHWA report on this can be found here:
https://international.fhwa.dot.gov/pubs/joint_report_resilient_infrastructure_fhwa_rws_january_2016.pdf

Recommendations:

- NRAs should seek to better understand the impact of the climate change on road infrastructure at a network level in order to carry out effective asset management. A network wide risk assessment enables NRAs
  - to identify systematic risks, which require amendments of regulation,
  - to identify the most affected parts/section within the network,
  - to rank adaptation measures depending on ascertained risk level,
  - and therefore, to optimise the use of resources.
- A consistent and transparent risk assessment methodology should be used to evaluate climate risk. This should be based on data as far as possible, but may need to include expert opinion where data is unavailable.
- NRAs should review the data they collect and how this is analysed, in order to identify additional data needs and analysis that would help to inform climate risk assessment.

4 Establishing carbon reduction and adaptation policy and targets

European and National policy and targets on carbon reduction and adaptation can have a large influence on NRAs. It is noted that the NRAs most active in these areas are generally based in countries with strong national policy and ambitious targets in relation to climate change. Generally policy and targets specifically relating to the transport sector and sustainable procurement have more of an influence than more over-arching targets.

Example: Sweden's national climate policy is reflected in NRA's targets

From 1 January 2018 Sweden has a new Climate Act. The Climate Act establishes that the Government's climate policy must be based on the climate goals and specifies how work is to be carried out. The Climate Act states that the Government must present a climate report every year in its Budget Bill and draw up a climate policy action plan every fourth year to describe how the climate goals are to be achieved. The goals are that Sweden shall have no net emissions of greenhouse gases in 2045, 75 percent lower emissions of GHG in 2040 and 63 percent lower in 2030 compared to 1990. A prior goal is to reduce emissions by 40 percent by 2020 compared to 1990. There is also a sector goal that the transport sector (domestic transport excluding aviation) shall have 70 percent lower emissions of GHG in 2030 compared to 2010.

The Swedish government together with the construction industry produced a roadmap setting out the steps to achieving carbon neutral infrastructure by 2045. The initiative was led by the industry; it involved 30 to 40 different organisations with Skanska leading the roadmap's development. Trafikverket together with other key stakeholders participated in its development. The roadmap was published in April 2018 and is available (in Swedish only) at http://fossilfritt-sverige.se/wp-content/uploads/2018/01/ffs_bygg_anlaggningssektorn.pdf

There are targets specific to the transport sector to support these ambitions, including some specific to transport infrastructure as this accounts for 5-10 percent of the road and rail GHG emissions. The Swedish Transport Administration, based on the national targets, has decided to set a long term goal to have climate neutral infrastructure by 2045, with interim targets of a 30 percent reduction in GHG by 2025 and 15 percent by 2020 compared to 2015 values. A goal for 2030 will be set in the beginning of 2019.

Example: The Dutch NRA sets a more ambitious target than national government

The Netherlands has a national policy to reduce its CO_2 emissions by 20% compared to 1990 values by 2020. The Dutch parliament is considering a new climate law which would set a 49% greenhouse gas emission reduction target by 2030 compared to 1990 levels and a 95% cut by 2050. As part of actions to achieve these targets sustainable procurement has been mandatory for all public authorities since 2015.

The Rijkswaterstaat (RWS) carbon reduction target is more ambitious than the national government. It aims to be climate neutral by 2030 and has set targets related to the use of asphalt (20% reduction in CO_2 emissions by 2025) and groundworks (10% CO_2 reduction in five projects by 2020). RWS has an annual carbon footprint of around 818 kilotonnes with materials such as asphalt, concrete, steel, aggregates and groundworks the main contributors. As such materials are a major part of its green procurement policy. It aims to use its procurement process to challenge suppliers to be more sustainable, using more sustainable working practices and materials. It seeks value for money considering the whole life cycle of the infrastructure. The main drivers for carbon reduction actions by RWS are the Paris International Agreement, national targets and RWS board decisions.

Example: Norwegian NRA carbon reduction targets

The goal of the NPRA is to reduce their carbon footprint for 2030 in relation to 1990 by:

- Operations and maintenance 50%
- Investments 40%

Example: Dutch climate change adaptation targets

The Dutch National climate change adaptation strategy (NAS), 2016 covers all sectors including infrastructure. There is also a Government climate change adaptation implementation programme as a result of the NAS, led by the Ministry of Infrastructure and Water Management. The Government has set a target in the Delta Programme for the country to become climate resilience by 2050. This means having the right policies in place by 2020 and then making sure critical infrastructure is less vulnerable to climate change. Both RWS (national roads), and provinces and municipalities (local roads) need to take the NAS into account.

Example: Climate change adaptation in Sweden

Trafikverket's Strategy for Climate Change Adaptation (link to PDF) published in 2014 sets out a number of areas it intends to focus on in order to adapt to climate change and maintain robust and reliable infrastructure. These include assigning responsibility for adaptation actions, undertaking research, incorporating consideration of climate change in planning and developing methods to decide which measures are cost-effective. Following this an action plan (link to pdf) was developed to identify the actions required to implement the Strategy. In 2018/19 the Swedish government have provided Trafikverket a budget to fund climate change adaptation actions focusing on risk reduction.

Recommendations

- NRAs need to set clear, measurable organisational targets as part of their climate change mitigation and adaptation policies. Targets need to include the supply chain as well as direct organisational emissions/resilience. These need to be challenging, but realistic.
- National policy and targets can be strong drivers for action and organisational targets should normally reflect these. However NRAs can also consider setting more ambitious targets that set nationally.
- The requirement on reduction of GHG emissions for a given year or project should be supplemented with an indicative, longer term target. This will give the consultants and contractors long-term rules to develop cost-effective solutions for the future.
- Progress on organisational targets needs to be measured and publically reported on.
- Targets need to be supported by action plans setting out areas for action in more detail, with timeframes and metrics. Consider if the use of tools, data portals and templates would help to make consistent data collection and analysis easier.
- There needs to be a consistent and transparent method of measuring progress to these targets. This may require the development of metrics, tools and data portals etc. to facilitate this.

5 Selecting a procurement approach

Procurement processes are heavily regulated at a national and European level in order to encourage a fair, competitive market. In broad terms, requirements can only legally be included in public procurement if it can be shown that they are clearly linked to the subject matter of the procurement and within the control of the supplier. Procurement regulations can create restrictions or perceived restrictions on NRA procurement processes.

As much of road construction and maintenance is now outsourced to private contractors, embedding climate change in procurement is vital to addressing both climate change mitigation and adaptation. The key issue is how to incorporate the contracting authority's needs for climate change mitigation and adaptation into procurement processes (including through development of output specifications, project requirements, evaluation criteria & approaches) in a way that is objective and not challengeable (Cambray, et al., 2009).

The inclusion of climate change and other environmental, social and longer term economic impacts in procurement can be referred to as sustainable procurement or green procurement. Sustainable/green procurement includes the use of low carbon emission materials, processes and products etc. to reduce carbon emissions and actions to adapt to climate change such use of sustainable urban drainage systems. Sustainable procurement takes social, economic and environmental aspects of construction projects into consideration and can be employed for different types of project including road design, construction and maintenance. Traffic operations are also a very important component of the GHG emission control and awareness; thus, reduction targets should be included in operation contracts as well. Specifying the use of renewable energy (e.g. using solar panels as source of power for electronic signs) is also part of sustainable procurement.

Over recent years there has been a growth in the recognition of the important role procurement has to play in addressing climate change, and there have been a number of national and European initiatives on this topic. Particularly for public procurement which covers the majority of NRA procurement. One of these initiatives is GPP (green public procurement) 2020 which aims to mainstream low-carbon procurement across Europe through the pledges of its members and by providing training and networking events.

The results of the survey conducted by the DeTECToR team at the end of 2016, suggest that the majority of European NRAs are using some form of tools or measures to control CO_2 emissions in their procurement processes. Around 34% of the NRA respondents said that they include requirements relating to carbon reduction in their tender evaluations and 32% consider carbon emissions when making a decision on which project to fund. However, only a small percentage of respondents (10%) are currently using carbon related KPIs in projects and maintenance contracts.

5.1 Methods of including climate change in procurement

There are two main approaches to including climate change in procurement. These may be implemented individually or combined.

Tender evaluation – Taking into account suppliers' sustainability credentials and/or the carbon reduction measures they propose to include in the project in tender evaluation is one approach. The simplest and most commonly used method is through the assignment of a specific (normally small e.g. 5%) percent to carbon reduction in the tender scoring. However, there are more novel approaches such as the Dutch CO_2 ladder/ DuboCalc approach. Here a

hypothetical discount is applied to the tender price depending on the carbon reduction performance of the organisation and the environmental impact of the proposed design. This provides more sustainable tenders with a competitive advantage (see Section 7.3.3 for more detail).

One of most important aspects with regard to using tender evaluation as a procurement approach is to ensure that the measures proposed are implemented either through applying incentivisation (see below) or assurance processes (see Section 9). Even if sustainability actions are included in the initial specifications, budget and time pressures, changes in the project design etc. can erode the sustainability of a project if these are not in place.

Incentivisation – Another approach is to incentivise the supplier to reduce the carbon emissions associated with a project. In this approach the NRA awards a bonus and/or malus related to specified targets such as percentage carbon reduction compared to a baseline, sustainability metrics or achieve a certain level in a sustainability assessment scheme (e.g. CEEQUAL, GreenRoads). A variation on this sometime used in Public-Private Partnerships (PPPs) is a points-based system where different types of infractions incur a certain number of points and when a threshold is reached, action is taken by the client. If using incentivisation the conditions for the award of the bonus/malus must be clear at the start and the value of the incentive sufficient to induce action.

Example: Sweden's approach

From the start Trafikverket decided its approach to introducing procurement requirements designed to reduce carbon emissions from its infrastructure projects would follow six basic rules:

- Take a long-term perspective
- Be technical neutral
- Include monitoring
- Provide incentives for doing more
- Impose a penalty for not fulfilling requirements
- Include an assessment of the impact

The approach developed involves measuring the carbon emissions associated with an infrastructure project over its lifecycle, setting carbon reduction targets and providing suppliers with financial incentives to meet these targets. Functional specifications are utilised which provide tenderers with the freedom to suggest innovative materials and designs which reduce carbon, but still achieve the required functionality. There was a wide-spread consultation process involving contractors, material manufacturers and consultants before the procurement requirements were introduced and an impact study was carried out to assess the likely impact of introducing the new requirements.

5.2 Potential barriers

The regulation of procurement can present real or perceived barriers to more novel approaches to procurement. Organisations can be risk adverse in regard to procurement laws and Governments may be concerned regarding the impact on the industry. For example if it will negatively impact on smaller local firms and benefit large multi-national companies which have the resources to invest in strong sustainability programmes. The experiences of NRAs which have implemented sustainable procurement do not appear to support these concerns. They have found the industry have for the most part welcomed the approach, and smaller companies have been among some of the most innovative in proposing sustainability actions. They have also found limited impact on the cost of tenders. The Dutch NRA also

report that OECD and the EU have mentioned the Dutch approach as best practice and it is fully supported by the EU tender law specialists.

Example: Impact of sustainable procurement on the industry in Sweden

The Swedish NRA found up to a 50 percent reduction in carbon over the project lifecycle can be achieved without increasing project costs. Often cost reduction and reduction of carbon go hand in hand. Even larger reductions (than 50 percent) can be achieved with only minor increase in cost. This is mainly because material type and quantity have a large impact on carbon emissions, whereas the main component of economic cost is labour. Therefore even if using lower carbon materials increases material costs by a few percent there is little impact on the overall project budget. Clients need to ask for low carbon materials and then suppliers will provide them.

Recommendations:

- Consider which procurement approach suits your organisation and the preferred type of contract. Both approaches have advantages and disadvantages. Including requirements in tender evaluation, requires strong monitoring and assurance to ensure commitments made at the tender stage are implemented. The incentivisation approach requires use of an LCA tool for consistent measurement and establishment of appropriate baselines and targets.
- It is recommended that technically neutral requirements on reductions of GHG emissions that describe what should be achieved instead of how it should be achieved are used. In this way the consultants and contractors can chose the most cost efficient solution.
- Be open to employing innovative types of procurement approaches to incentivise climate change mitigation and adaptation. The experiences of some NRAs have shown it is possible to do this within EC procurement laws and without adversely affecting the industry or increasing the costs of projects.

6 Assessing impact and stakeholder engagement

Dialogue with suppliers is important when introducing a new procurement approach, both to raise awareness of the new requirements and reasons behind them but also to identify any unintentional impacts they may have on the industry. If suppliers fully understand the changes and have a chance to provide feedback, implementation is likely to be much smoother. It is also important once the new approach has been implemented to regularly review the approach and seek feedback.

6.1 Methods of stakeholder engagement

Stakeholder engagement can take several forms, and a mixture of methods is likely to be most effective.

Workshops: It is useful to gather together suppliers and NRAs around one table so they can discuss the new requirements, if targets are appropriate and reach an understanding how of how these can be achieved and demonstrated.

Information seminars: Periodic information seminars/webinars for the suppliers on the climate change related requirements, how to use the carbon assessment tools and how "carbon/environmental' financial incentives or additional points can be gained by the contractors are beneficial.

Collaboration and innovation days: These types of events can be also organised by NRAs to encourage exchange of knowledge and ensure greater collaboration. Presenting the most recent state of the art in climate change related requirements and technologies to mitigate the negative effect of climate change and providing an opportunity to meet and discuss any issues. During such events innovative approaches regarding asset management to better optimise costs related with repairs and proactive maintenance to preserve the infrastructure life can also be presented/encouraged.

Use of online tools: Tools such as collaboration platforms or discussion portals can help in the exchange of knowledge and good practice. These tools can be used by the NRAs and their suppliers to help them to exchange good practice and discuss experiences.

Example: Industry engagement in Sweden

The Swedish NRA Trafikverket has carried out various forms of stakeholder consultation as part of the introduction of the new procurement requirements. Before applying the new procurement approach it consulted widely with suppliers and carried out an assessment of the potential impact of introducing the new requirements. In general suppliers were supportive of the proposals and the impact assessment suggested there should be little impact on project cost with reduction targets up to 30%.

In autumn 2018, after the requirements had been in place for two years, Trafikverket commissioned a research project to carry out a review of the new procurement approach and map out its approach beyond 2029. During this research project the consultant interviewed entrepreneurs, consultants and suppliers about their experiences with the new procurement requirements. They were asked if the targets were appropriate, how easy the tool was to use and how further carbon reduction could be achieved. One of the biggest challenges is establishing an appropriate baseline level and reduction target, and the suppliers sometimes challenged the baseline assessment. The consultants have selected three projects to review in more detail.

As the procurement approach has been employed on projects due for completion in 2020 or later it is too soon to be able to evaluate the overall impact. However, Trafikverket consider the approach to have been successful and are expanding it to include lower value projects and maintenance projects in addition to new build. Based on Trafikverket's experience up to 50 percent reduction in carbon can be achieved without seeing any increase of the overall cost of the project. In most cases, suppliers are far exceeding the targets set. Some suppliers are very knowledgeable about carbon reduction actions, others are less so and would prefer to have a greater steer from the NRA. Trafikverket held a conference for 70 - 80 of their suppliers and asked them whether they would prefer to be provided with specific carbon reduction actions and KPIs rather than set a high level target. The response from the majority of suppliers (70-80%) was that they prefer the NRA to produce functional requirements and set high level targets enabling them to suggest carbon reduction actions that meet these. It wasn't necessarily the small organisations which struggled with carbon reduction; often small suppliers can be very innovative. Trafikverket hope that the new requirements will encourage those who are less knowledgeable about carbon reduction to upskill their staff so they can obtain the bonuses.

Example: Industry engagement in the Netherlands

Suppliers have broadly been accepting of the use of DuboCalc and happy to use it. They found that not only does it improve sustainability, but it also leads to better, smarter designs with reduced costs. RWS believe that the relationship with their suppliers should be built on support, trust and understanding. They recommended starting to include climate change in procurement slowly starting with the high value projects. Initially a low value discount should be awarded for sustainability criteria to minimize cost effects, once suppliers are used to this it can be increased. If suppliers are already used to a high proportion of the award criteria being related to quality it is easier to expand this to include sustainability. As price is always a factor in project awards, the participants will still work to minimise cost and be competitive.

Recommendations:

- **Define and apply the vision**: NRAs need to engage the market early and openly to develop a shared understanding with potential suppliers. The market needs to know the authority is serious about addressing climate change. NRAs need to be open to challenge and ready to enter dialogue about relative priorities (e.g. in striking a balance between carbon management and adaptation).
- **Inform and consult**: NRAs need to provide the suppliers with the information on the new requirements, but also be ready to consult on issues such as the most appropriate targets and bonus levels.
- **Guidance and support**: NRAs need to develop support for suppliers, for example holding workshops and training on new tools, providing good practice examples of what they are looking for from their suppliers and guidance on the new requirements.
- **Gradual introduction**: It is often best to introduce new requirements gradually, for example on certain types of project or in a certain region of the network.
- **Review and improve:** Once the new system is implemented it needs to be periodically reviewed so any improvements can be identified or issue addressed.

7 Implementation in procurement

7.1 Contract type

The implementation of the selected approach depends to some extent on the contract type used by the NRA. Typically NRAs tender contracts for major upgrades (e.g. widening roads) and new build as capital projects, whereas routine maintenance and operations are tendered on a geographical basis for a set amount of time as maintenance projects. For each category, there are a variety of procurement and delivery approaches. Capital project procurement approaches include private financing. Approaches include:

- Design-Build (DB)
- Design-Build Operate Maintain (DBOM)
- Design-Build Finance Operate (DBFO)
- Build Own Operate (BOT) & Build Own Operate Transfer (BOOT)

Individual projects may be tendered under framework contracts covering a particular region and period of time.

In regard to maintenance contracts the Finnish Road Enterprise (Pekkala, 2002) identified an increasing use of long-term maintenance contracts (i.e. greater than 7 years). The most innovative include the following parameters:

- Long-term agreements
- Partnering (both with the client & sub-contractors)
- Lump sum contracts
- Using quality-based contractor selection criteria
- Provide some of the sub-contractors with the same long-term agreement or at least sharing the risks/rewards
- Utilising outcome-based criteria
- Ability to use climate change requirements throughout the length of the contract

7.2 Performance specifications

The use of performance specifications and outcome based criteria has increased in response to the trend for greater outsourcing of construction and maintenance activities, and consequently the need to infrastructure owners to have a suitable audit and quality processes. Performance criteria have been widely used in capital projects in other infrastructure sectors, for example in the building technology sector. The performance criteria for capital projects can be quite easily incorporated into Design-Build delivery methods or their related Design-Build models (Design-Build Operate Maintain and Design-Build Finance Operate). For pavements these might take the form of a minimum level in a condition indicator such as skid resistance or may include a warranty for a specific time period. Sometimes these performance specifications have been developed from other industries that have successfully implemented them. Among the reasons for the progression to performance specifications are the potential for cost savings, risk transfer, and providing the contractor with more flexibility to utilise innovative and more efficient means of producing the desired performance results. If a NRA uses “Outcome-Based Criteria” in maintenance contracts, the process is somewhat different, as the NRA specifies the desired “outcomes” and the contractor needs to provide the proper strategy to meet these stipulated levels. A significant

failure or risk would be to apply inappropriate “Outcome-Based Criteria” which could result in poor quality or failed roads, or even the reverse scenario producing expensive over-engineered roads.

Performance specifications related to climate change considerations can be embedded into the technical specifications for capital and maintenance contracts. Care must be taken in determining the satisfactory or desired levels so that there is neither a large increase in cost nor a large decrease in the quality and performance of the roads. The NRAs need to define the outcome-based criteria that meet or exceed the quality requirements in the contract. It is very important that there is a mutual understanding between the industry and the procuring road agency organisation on what repercussions or end results might occur if the contractor does not meet the specified requirements.

7.3 Examples of approaches to including climate change in procurement processes

7.3.1 *Sweden*

In April 2015 the Swedish Transport Administration made it mandatory to use its LCA tool Klimatkalkyl (see Section 0) to calculate the GHG emissions and energy for all new infrastructure projects with a total budget over 50 million SEK (5.4 million €) which will be completed after 2020. Since February 2016 the tool has been used to set procurement requirements in projects that meet these criteria.

As part of the early project planning process Trafikverket establishes a baseline carbon value for each relevant project using the Klimatkalkyl tool. It uses the tool to compare different options, for example comparing the GHG emissions associated with different routes, or tunnels with bridges. Once a route is selected the assessment enables the identification of the main contributors of GHG and an internal workshop is held to identify potential measures to reduce GHG measures and set a realistic carbon reduction target for suppliers. Trafikverket defines the carbon reduction target for the project as a percentage of the baseline and assigns the bonus available for exceeding this target (currently this is a maximum of 10 percent of the project value). If a significant change to the scope of works is made during the project the baseline is updated, but the target is retained.

Although the targets will vary depending on the project, on average the target reductions are:

- 15% for contracts ending 2020 - 2029
- 30% for contracts ending 2030 or later

The NRA provides functional specifications, together with the baseline assessment and reduction targets. Suppliers submit tenders including measures to reduce GHG emissions and their estimate of the carbon savings this will produce calculated using Klimatkalkyl. In their tenders the suppliers do not need to show their calculations how to reduce the emissions. They only guarantee that they will achieve the target. The tenders are not evaluated for their sustainability, instead a systems of bonuses and penalties are employed to provide a financial incentive for reducing carbon. During the contract Trafikverket discuss the proposed measures with the contractor so that both parties are sure that they will be achieved. At the end of the project a climate declaration is submitted by the supplier providing the carbon value based on the actual materials and quantities used. If low carbon materials are used which are not contained within the database the emission factors need to be verified by third party EPD auditors. The EPDs stored in the tool are available for download for suppliers (in Swedish only). Trafikverket obtains input from the industry

regarding the EPDs and updates the tool accordingly. Development of the EPDs is a transparent process and sources are available (where it comes from and who developed it).

Once the climate declaration and any supported EPDs are submitted Trafikverket applies its bonus and penalty system:

- A bonus is paid if the supplier achieved a reduction of GHG emissions greater than the target set. The bonus given normally corresponds to about 1% of the contract value for a reduction of 10% more than the requirement. There are plans to give bonuses up to 100 % reduction for projects due to complete 2030 or later. They consider that these bonuses will not need to be more than 2 percent of the contract value for 100% reduction.
- If the requirements are not achieved, the contractor will not receive the carbon bonus or other bonuses e.g. for delivering on time.
- The amount of bonus or penalty applied is based on how far above or below the target the carbon value is.

From March 2018 there are also requirements on materials and fuels in smaller projects (below 50 million SEK) and maintenance projects regardless of size. In these types of project the requirements are directly on the climate performance of the materials and fuels since climate calculations are not currently carried out. In 2019 requirements on pavement contracts and on summer and winter maintenance will also be introduced.

In parallel with the new procurement requirements Trafikverket has been working with suppliers on reducing the carbon associated with commonly used carbon intensive materials such as asphalt and steel. They have been reviewing their procurement requirements on selected materials such as steel, concrete and cement.

Trafikverket's advice to other NRAs:

- Start by requesting suppliers to provide carbon calculations for projects rather than introducing carbon reduction requirements right away.
- Strengthen the requirements (i.e. increase carbon reduction) gradually over time in line with national and internal targets. At the same time increase the level of reduction needed to achieve a bonus.
- Get the industry on board from the beginning and align with national goals and targets.
- It is important to carry out an impact assessment together with the industry and have initial interviews with suppliers before implementing the procurement changes.
- While setting up the targets it is necessary to keep in mind that they need to be realistically achievable within the budget.
- Outreach to entrepreneurs and consultants, organise conferences, seminars, etc. to engage the industry in your carbon reduction plans.
- Set internal goals so everyone is aware of the approach being taken and the timeframe.

7.3.2 *Norway*

The Norwegian NRA (NPRA) do not have any fully implemented mechanisms to reduce carbon through procurement. However, they are testing a new approach within selected projects as part of a research project called Krakk. NPRA (through a project with the University of Agder) have found that on construction sites almost two thirds of the carbon footprint comes from the materials and around a third from fossil fuel powered plant vehicles

and transport. The main material contributors are concrete and cement manufacturing, including reinforcement steel, and asphalt. Therefore their approach on materials focuses on a bonus/malus system connected to high carbon materials and the introduction of zero-emission (electric/battery/hydrogen) machinery.

Contractors receive a bonus for using less CO_2 intensive materials (concrete, asphalt, steel) and using site plant and vehicles not powered by fossil fuel. The EPDs can be either certified EPDs obtained from third parties or self-produced by the contractors; to obtain the bonus they must be site-specific. Material quantities and the carbon factor from the EPD are the basis for the calculation. NPRA will employ third party verification (by certified EPD verifiers) to carry out random checks on the EPDs generated by contractors. Currently NPRA is only using EPDs for concrete and asphalt but eventually they also want to include construction steel.

Within the KraKK-project the EPD-bonus/malus-system is being piloted on selected projects. In principle the bonus is oriented on the extent of carbon emission reduction, based on the determined project specified requirements. The same applies - the other way around - for penalties paid by the contractors if the requirements are not met.

For example, the KraKK-project has proposed the following bonus payment for the use of zero carbon machines or vehicles and will test this in the different pilot projects:

- Emission free excavator > 25 tonnes receives 400kr/h (40€/h); Maximum 2,000h or 800,000kr (80,000€).This is a standard Caterpillar excavator rebuild in Norway. It can be used for approximately 5 hours' work before charging the battery. The first few were delivered in late 2018.

The main objective is to influence the industry by establishing Norway as a suitable test market for heavy electric/battery/hydrogen-equipment built elsewhere, in the same way as the country has been for small cars/family cars. This is based on the fact that Norwegian electricity is 96-98% renewable from waterpower and has a strong grid.

NPRA sees the following advantages in using the bonus/malus system compared to a requirement based approach:

- No competitor will be excluded from the procurement/bidding process (otherwise: the competitor must be excluded if they cannot fulfil the requirements)
- Flexibility (project specific)
- Incentives to improve the performance constantly during the contract phase
- No formal limitation of paid results

The advantage of a bonus system is that contractors are incentivised to improve climate performance as part of the contract. It is intended that the contractor assumes they will receive the bonus when calculating their tender costs. The bonus needs to be greater than the higher cost of low carbon materials.

The NPRA LCA tool VegLCA (see Section 2.3) is also being used in the procurement process of the pilot projects. It is not connected to the bonus/malus system, but is used for environmental impact budgeting as part of the road administration procurement decision-making process.

7.3.3 *The Netherlands*

The Dutch NRA, Rijkswaterstaat (RWS), is required by national government to implement sustainable procurement and has set organisational targets related to the carbon footprint of the organisation and its supply chain. Its approach to achieving this is to use functional specifications for infrastructure projects, and create commercial incentives for suppliers to submit a more sustainable tender. This allows suppliers the flexibility to set their own sustainability goals and differentiate themselves from the competition though innovations to improve sustainability. RWS supplies the tools and framework for assessing sustainability, which means all suppliers/projects use the same methodologies and data so there is a fair comparison. The formal procurement requirements are supported by efforts to work with the supply chain, encouraging innovation and sustainable working practices. This includes instigating targeted initiatives to address carbon intensive materials such as Asphalt Impuls (see Section 8.2).

RWS includes sustainability in the project goals from the start and establishes its ambitions for the project. It identifies measures to reach these goals which are included in the tender evaluation criteria. RWS uses a tool called the Sustainable Planning Circle to review twelve aspects of sustainability, such as water, accessibility, energy and carbon and identify potential actions to address these with the planned project. The Ambition Web is used to identify project requirements under the sustainability topic headings. Project sustainability requirements are a mixture of national standards (e.g. use of sustainably grown timber), organisational requirements (e.g. use of LED lighting) and project specific requirements. RWS employ two main tools to support their sustainable procurement approach - DuboCalc and the CO_2 performance ladder

DuboCalc is an LCA tool which calculates the environmental impact of a project over its lifetime (see Section 0). The CO_2 Performance Ladder (PL) is a concept developed by ProRail, the Dutch rail infrastructure owner, but is now also used by RWS (and other companies). The PL is a carbon management certification scheme to help organisations assess and improve their approach to reducing CO_2, but it is also used in procurement to compare organisation's approach to carbon reduction. Suppliers gain an advantage during the tendering process according to their level on the ladder. There are five levels or rungs on the ladder, with 1 being the lowest and 5 the highest. Carrying out actions such as procuring green energy, more efficient uses of materials move an organisation up the ladder. To achieve the higher levels innovation and partnership with other organisations is required. Suppliers are awarded a 1 percent hypothetical reduction in the price of their proposal during the tender evaluation for each rung of the ladder they have achieved. This provides a significant advantage over less sustainable competitors.

The PL has had a large influence on Dutch construction industry, with many suppliers achieving a large reduction in CO_2. Around 850 certificates (over 3000 companies) in infrastructure and associated sectors (engineering, dredging, ICT, waste management/recycling) have been issued and over 75 (public) commissioning parties use it in their tender procedures (equivalent to around 4 billion euros of tender value per year). A handbook provides details of what is required at each level, and an organisation's level needs to be independently verified by a certification body. Organisations are awarded a CO_2 awareness certificate which is reviewed every three years. SKAO are now the manager and owner of the ladder. A guide for clients wishing to implement the PL as part of their sustainable procurement policy is available on the website https://www.skao.nl/home_en

The PL operates at an organisational level working in tandem with the project level DuboCalc. The PL assesses the sustainability of organisational working practices and DubCalc the environmental impact of the proposed design.

RWS evaluate tenders based on the price/quality ratio. Quality criteria for each project are developed to align with the project objectives and RWS's overall policy. The assessment of quality includes sustainability. RWS provides functional specifications for the project including a maximum Environmental Cost Indicator (MKI) value based on a reference design assessed using DubCalc. It also provides suppliers with access to the DuboCalc assessment tool, handbook and the calculation procedure which will be used to monetarise the MKI. The proposal submitted by the suppliers includes a description of their design, the bidding price, MKI value calculated using DuboCalc and PL level. As a result designers compare the environmental impact of different designs, suppliers try to use low temperature asphalt, more recycled and secondary materials and incorporate renewable energy projects into their design.

When comparing proposals RWS monetarises the MKI value; subtracts this from the bidding price and applies the PL level discount. The suppliers offering the maximum MKI will receive no MEAT (Most Economically Advantageous Tender) discount, while those offering less than this will obtain an increasing level of discount up to a maximum discount value for the minimum MKI submitted. MEAT discounts are given for other criteria too (as set out in the contract specifications). The adjusted prices of each proposal are compared and the supplier with the lowest value selected.

(Bidding price) – (%bidding advantage due to PL level) – (MEAT MKI value) – (other MEAT values) = adjusted bidding price

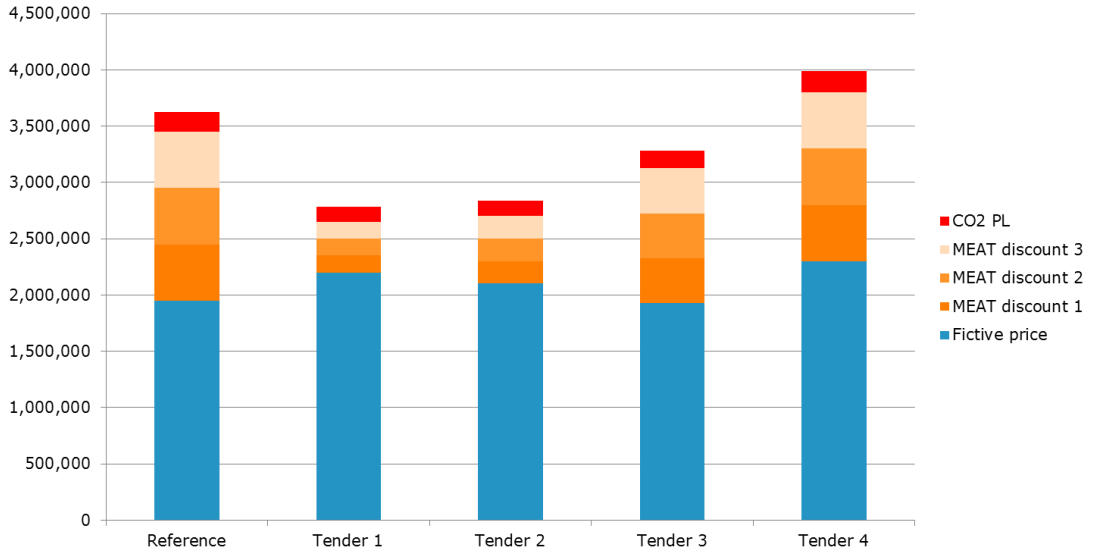


Figure 11. Tender evaluation using MEAT criteria

Once the tender is awarded the MKI and compliance with the PL commitments of the stated level become contract requirements. The MKI value is recalculated at delivery with the real data and independently verified. If the MKI meets the promised value, the supplier is paid the submitted price. If the MKI is exceeded a financial penalty is imposed. The fine imposed is normally 1.5 times the difference between the promised and delivered MKI value. If the MKI

is lower a bonus is awarded. The PL awareness certificate needs to be shown a year after the contract is signed.

Example: Renovation of the N61 Hoek Schoondijke, the Netherlands
RWS tendered a project to renovate the N61, including new pavement construction (from foundation to surfacing), new lighting and vehicle restrain system.

Figure 12. Renovation N61 Hoek to Schoondijke (Source: RWS)

The estimated cost of the renovation was €60 million and the MEAT criteria were:

1. External affairs management (traffic delay, vulnerable road users, planning and phasing).
2. Sustainability (Environmental Quality (MKI))

The maximum discount available due to sustainability was €2 million (0.8 million for minimising carbon) and for other MEAT criteria €8 million. The winning tenderer submitted a proposals for €55 million, received a 5% discount for their rating on the CO_2 PL, 1.5 million discount for their MKI score and €5 million for other MEAT criteria. This produced a corrected bidding price of 45.75 which was the lowest value.

Recommendations:

- Sustainable procurement for all purchases (materials, service, maintenance, construction, vehicles, etc.) needs to be part of NRAs climate change policies and targets.
- Be open to more innovative types of procurement approaches to incentivise climate change mitigation and adaptation. The experiences of some NRAs have shown it is possible to do this within EC procurement laws and without adversely affecting the industry or increasing the costs of projects.
- The three NRAs included in this project (arguably some of the leading NRAs in this area) have all set carbon targets for individual projects, developed an LCA tool to measure carbon at the project level and provided financial incentives for suppliers to meet/exceed the targets they set. They all report that this is successfully reducing carbon emissions.
- EPDs are becoming increasing important. Often materials are used across industry and sourced internationally. NRAs should participate in national/ European discussions on environmental data and its assurance.
- Learn from the experiences of other NRAs and other industries on how to embed sustainability requirements in procurement (e.g. by using the DeTECToR collaboration platform.

8 Embedding in NRA operations

In addition to the embedment of climate change in procurement, NRAs can take other actions to include it in their operations; asset management and economic appraisal (see DeTECToR deliverable 6.3 '*Guidance on including climate change in economic appraisal'*).

8.1 Climate change adaptation

Climate change adaptation is most often embedded in operations and procedures, rather than directly procurement. For example by including it in:

- **Planning** - The EIA European Directive was updated in 2014 to include disaster prevention and climate change impacts. Implementation of the Directive through the requirement for a comprehensive risk assessment including climate change impacts to be carried out will enable the identification of potential hazards and inform alignment and design decisions. This assessment should be multi-discipline.
- **Standards** – Modifying standards to take account of climate projections, rather than basing them on historic weather patterns will help to make infrastructure more robust.
- **Project specifications** – Including climate change in project specifications for example requiring suppliers to review climate projections, carry out a climate change risk assessment or make provision for higher levels of flooding.
- **Asset management** – Carrying out a network wide risk assessment to identify the assets most at risk (e.g. using the DeTECToR risk assessment and CBA tool) and focusing efforts to increase resilience of the high risk sections. Including it in economic appraisal and budget planning.
- **Operations** – Improvements to incident management in order to reduce the impacts of a weather event when it does occur and quickly recover. This includes actions such as requiring suppliers to have disruption management plans for different types of event, to check drainage when heavy rainfall is forecast and ensuring there are procedures in place to capture lessons learnt from severe events.

Example: Embedding climate change adaptation in the Netherlands

RWS incorporate climate change adaptation in new build through modifying design standards to account for climate change and also as part of the EIA at the planning stage. For example it has increased drainage capacity requirements by 30% in line with climate projections in its design standards. EIA takes into account both climate change mitigation and adaptation.

RWS provides climate change adaptation guidance for their suppliers (in Dutch). This provides guidance on what should be included in different project stages; planning, design, construction etc. It also provides links to further information e.g. from the EEA or CEDR. RWS review the quality of supplier plans and make sure they are climate resilient (as well as meeting other criteria such as noise, air quality etc.). If not they will ask the design consultants to modify their plans. The designers should follow RWS guidance on climate change adaptation and make use of information from EEA or CEDR. This applies to large multi-year projects. RWS are exploring how to include climate change adaptation in service level agreements, but are currently unsure how this will be done. There are multiple requirements in service level agreements.

Advice to other NRAs on adaptation:

- Good maintenance is the first step. Well maintained roads are less vulnerable.
- When designing new roads consider incorporating (cost-effective) features to make them more resilient.
- Assess the functionality of the present network and identify the vulnerable spots, so you can focus on these.
- Awareness-raising within the organisations is important.

Example: Embedding climate change adaptation in Norway

NPRA have been carrying out climate impact assessment for the last 10 years. They started by identifying the risks from climate change for different types assets such as roads, bridges, culverts etc. More recently they have being assessing individual road sections together with the contractors using a virtual drive through and stopping to discuss problem areas. Representatives from different specialisms such as pavements, bridges, drainage etc. attend. They use the VegROS tool to produce a risk score for each section of road. The assessment is carried out annually on road stretches covered by the various maintenance contracts. It is performed per geographical contract: looking at challenges already known and new ones occurring. One basis for the assessment is the results of the general vulnerability assessment carried out for the various type-categories of road asset elements. Actions for the road sections that have a high level of risk are agreed between NPRA and the contractors.

Based on those experiences, guidelines for design, operation and maintenance have been revised (e.g. flood proof alignment, upgraded drainage capacity, improved water management). Climate change adaptation is not currently included directly in the tender specification and evaluation processes, but NPRA and considering requiring a certain competency level from suppliers.

The research programme “Klima og transport” (climate and transport) initiated in 2007 focused on climate change impact and risk assessment as well as on the derivation of adaptation measures in order to improve design, construction and maintenance of the road network in order to adapt to climate changes. The final report was published in 2013 and the findings are now being implemented. The “Climate and Transport” programme defined four main groups of adaptation measures:

- **Planning, design and construction of new roads**
  The effects of climate change should be considered as an integrated part of the planning and development of a road project. For example, the road should be placed in areas less prone to landslide and flood hazard, or where this hazard is easier to handle.
- **Operation, maintenance and management of existing road network**
  Adaptation measures should preferably be carried out as part of scheduled maintenance. It is planned to include Climate Change in the risk assessment.
- **Preparedness and contingency plans (stepwise preparedness)**
  Different levels of preparedness were defined for the case of a climate event occurs (i) Yellow: possible threat under special conditions and elevated preparedness; (ii) Orange: threatening weather situation, could cause damage in some places and requires a high level of preparedness; (iii) Red: threatening weather situation in several places, requires an emergency level of preparedness. Part of the preparedness strategy is the web portal www.xgeo.no., an expert tool used for preparedness, monitoring and forecasting of floods, landslides and avalanches; with maps and time base compiled data from stations and models with events and field observations.
  An improved template for an emergency plan for natural hazard has been formulated and is being implemented in operation contracts. The plan includes more elaborate use of weather data and map-based information concerning the specific road stretch. Contractors can receive information concerning flood and landslides: history, statistics, repair carried out, special problems etc.
- **Improving the knowledge base for adapting to climate change**
  Support climate research and implementation of new knowledge. Interpretation of climate research for practical use is a precondition for adaptation. Improved monitoring of weather events. Improving maps and GIS databases. Good interface solutions, functional databanks for landslide data, better documentation of events in every-day operations.

Example: InnovA58, the Netherlands

RWS trialled the use of the ROADAPT risk assessment methodology when planning a project to widen a section of the A58 motorway. It also worked with the USA to implement the Federal Highway Administration (FHWA)'s sensitivity matrix and Vulnerability Assessment Scoring Tool (VAST) for comparison. The FHWA also trialled the two approaches on a highway project in Washington State. The call for tenders for the design of the InnovA58 included a section on climate resilience requirements requiring tenders to develop climate change adaptation measures, make use of national climate projections and carry out cost-benefit analysis and other evaluation on the proposed adaptation measures. Accompanying the call was the results of the ROADAPT risk assessment. The tender requirements also included other sustainability criteria. Additional information is provided in the links below:

https://www.platformomgevingsmanagement.nl/wp-content/uploads/2018/06/artikelmyrtheleijstrakeesvanmuiswinkelwimleendertsetomasbles-developmentofaclimateadaptionstrategyfortheinnova58highwayinthenetherlands.pdf

https://international.fhwa.dot.gov/pubs/joint_report_resilient_infrastructure_fhwa_rws_january_2016.pdf

8.2 Climate change mitigation

In addition to procurement NRAs can reduce carbon through working with industry, providing guidance on sustainable design, awards/competitions for suppliers and setting requirements in relation to recycled and reused materials.

Example: Asphalt Impuls, the Netherlands

Carrying out an LCA assessment helped RWS to identify the major source of emissions; asphalt, concrete, groundworks including dredging. They have instigated initiatives to target these; the concrete agreement, asphalt Impuls and green deals. They are also focusing on the circular economy.

Asphalt Impuls is a sector wide programme with commitment of all partners in the asphalt supply chain which includes sustainability and CO_2 reduction. Instigated by RWS, programme partners include contractors, designers, clients / road managers, suppliers of raw materials and equipment, quality managers and researchers. Contractors and suppliers have the opportunity to carry out research into new asphalt mixes and construction methods and have their innovations recognised by clients.

https://www.crow.nl/thema-s/infratechniek/asfaltverharding/asfalt-impuls (in Dutch).

Example: Concrete sleepers, Sweden

In addition to the inclusion of carbon reduction targets in the larger projects and the specific requirements on materials and fuels in smaller projects and maintenance regardless size Trafikverket also has requirements on railway materials that the administration buy directly for use of the contractors. For example they worked with the producers of concrete railway sleepers and achieved high CO_2 reductions without increasing cost (see figure 4 below). By decreasing the dimensions of the sleepers, which were for the most part unnecessarily large for the load, both carbon emissions and cost was decreased. Trafiverket has found that achieving climate neutral infrastructure does not necessarily mean an increase of total project cost, and sometimes reducing carbon can also save money.

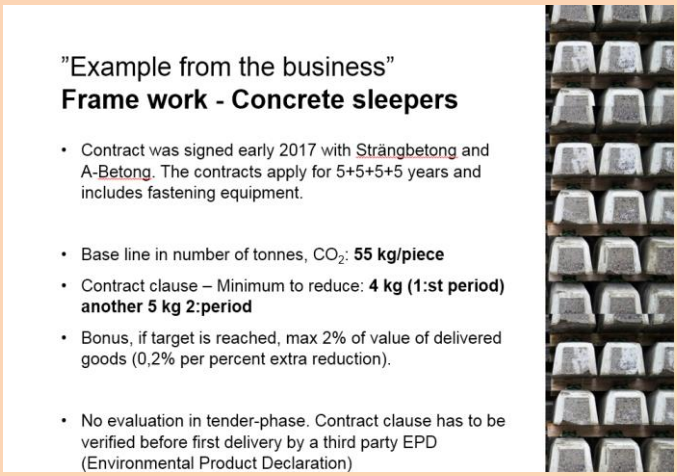


Figure 4. Concrete sleepers example

They are also planning on introducing requirements for zero emission plant to be used during construction, e.g. electric battery powered diggers.

Recommendations:

- Review each step in the project lifecycle and identify points where requirements relating to climate change can be added into existing processes e.g. stage gate requirements. Include planning, design, procurement, during construction, maintenance and end-of-life. Include all types of asset and project in the assessment, but the effort required by the NRA and supplier should be proportional to the project size.
- Take actions to embed climate change consideration in the organisation as well as in projects. For example providing appropriate support for staff in terms of training specific to their role, including climate change in staff development objectives and having designated roles accountable for climate change mitigation and adaptation.
- Engage the industry in efforts to reduce carbon and improve resilience. Suppliers and manufacturers may have ideas to reduce carbon, but need to be sure there is a market.
- Procurement requirements should be complemented with research and development activities together with the consultants and contractors. Focus should be put to reducing the cost of promising solutions with large potential to reduce GHG emissions. Barriers for using cost efficient solutions should be identified as well as solutions to unlock these.

9 Assurance and benchmarking

With a supplier compliance assurance mechanism, NRAs are able to set specific requirements and goals in cooperation with the market to ensure the procurement requirements are developed in a transparent way and any corrective measures are deployed in compliance with suppliers. Assurance of climate change related requirements may take several forms. During progress meetings, the NRA should question the sustainability actions being taken, as well as progress against the project schedule and budget. If there are sustainability targets, metrics or action plans these should be reviewed regularly, so any issues can be addressed before the project is too advanced. At the end of project the actions taken to reduce carbon and increase climate resilience should be compared against the specifications as part of the project sign-off. Where specific data has been submitted, for example the project's carbon footprint, these need to be checked. In some cases third party verifiers may be required, for example if the supplier has created or used EPDs that differ from default values. The effort put into assurance should be proportional to the size of the project.

According to the general definition benchmarking is an internal organisational process which aims to improve the organisation's performance by learning about possible improvements of its primary and/or support processes by looking at these processes in other, better-performing organisations. A condition for improving processes is to know them; this requires detailed knowledge about the organisation's own performance and performance of other organisations. Benchmarking involves, therefore, a self-evaluation including systematic collection of data and information with a view to making relevant comparisons of strengths and weaknesses of aspects of performance, usually with others in the sector. Benchmarking identifies gaps in performance, seeks new approaches for improvements, monitors progress, reviews benefits and assures adoption of good practices.

The goal of benchmarking in procurement is to enhance the implementation and inclusion of climate change related technical provisions into procurement of road assets and compare it with other NRAs who are going through the same processes and similar procedures. The benchmarking mechanism needs to be developed to include climate change requirements in procurement challenges to fill the gaps between NRAs and suppliers for maintaining the specified quality of end products (specification for certain assets impacted by climate change).

Benchmarking can also be carried out between projects of similar types or between contractors in order to better understand why some have performed better than others and encourage exchange of good practice. However as each project is different, care needs to be taken in understanding the reasons carbon emissions or climate resilience may differ. The performance criteria being used for assessment/benchmarking need to be set out at the beginning of the project. It will take time to gather information on sufficient projects to be able to robustly benchmark them. In large programmes of work, software which suppliers can use to submit environmental data and environmental dashboards can be helpful.

Example: Third party verification of EPDs in the Netherlands

Once the contract is awarded the MKI and compliance with the PL commitments of the stated level become contract requirements. The MKI value is recalculated at delivery with the real data and independently verified. The PL awareness certificate needs to be shown a year after the contract is signed.

The Dutch NRA does not benchmark projects, but it does record the carbon reductions for each project. On average it has seen a 40% reduction in the carbon generated by projects as a result of the new approach.

Example: Random checks in Norway

The Norwegian NRA (NPRA) will employ third party verification (by certified EPD verifiers) to carry out random checks on the contractor generated EPDs.

Example: Third party verification of EPDs in Sweden

At the end of the project a climate declaration is submitted by the supplier providing the carbon value based on the actual materials and quantities used. If low carbon materials are used which are not contained within the database the emission factors need to be verified by third party EPD auditors.

Recommendations:

- Monitor progress on sustainability requirements throughout the project. Clients should question suppliers on sustainability performance and show that this is important to them.
- The NRA staff overseeing projects need to have the information and training to be able to confidently challenge suppliers on sustainability performance.
- At the end of the project the actual design and material use should be compared to the proposal and/or baseline. Any lessons learnt or good practice identified should be disseminated within the NRA and if confidentiality allows the wider industry.
- Benchmarking with other NRAs can identify opportunities for improvement and instigate sharing of good practice. Awards and recognition of good practice can also incentivise suppliers.
- Benchmarking projects within an NRA can help to identify the factors which increase carbon/reduce resilience and support efforts to consistently implement climate change policy.
- Monitoring of separate contractors for all contracts that they have done can help to identify the factors which make a supplier organisation more sustainable. By comparing the results of different contractors and benchmarking them a form of competition can be established.

10 Reviewing and improving/expanding the approach

Once the new procurement approach or modification to procedures has been implemented it needs to be reviewed after an appropriate period of time to identify any issues and to ascertain if it is having the desired response. If successfully implemented in one type of project or region the review could also evaluate the feasibility of expanding the approach to other types of project or regions.

Example: Review and expansion of new procurement approach in Sweden

In 2016 the Swedish NRA implemented their new procurement approach for all new infrastructure projects with a total budget over 50 million SEK (5.4 million €) which will be completed after 2020. In autumn 2018, after the requirements had been in place for two years Trafikverket commissioned a research project to carry out a review of the new procurement approach and map out its approach beyond 2029. During this research project the consultant interviewed entrepreneurs, consultants and suppliers about their experiences with the new procurement requirements. They were asked if the targets were appropriate, how easy the tool was to use and how further carbon reduction could be achieved. The consultants selected three projects to review in more detail. The project was completed in December 2018.

Trafikverket is currently piloting the expansion of the approach used in the large projects in selected pavement contracts and maintenance projects. The aim is to roll this approach out across all types of contract. As an interim measure from March 2018 the NRA set requirements for certain materials and fuels in smaller projects (below 50 million SEK), and in maintenance projects regardless of size. In 2019 requirements on pavement contracts and on summer and winter maintenance will be introduced.

Example: Expanding on the KraKK pilot projects in Norway

The Norwegian NRA is piloting a bonus/malus carbon reduction system on selected projects as part of the KraKK research project. Bonuses/malus are awarded based on EPDs of carbon intensive materials (concrete, asphalt, steel). Their LCA tool is also being used in the procurement process of the pilot projects. VegLCA is also being used in the procurement process of the pilot projects. It is not connected to the bonus/malus system, but is used for environmental impact budgeting as part of the road administration procurement decision-making process.

If successful the plan is to roll this approach out to other projects, and in the future encompass more materials and expand on the role of VegLCA.

Example: Building on the procurement approach and adaptation pilot studies in the Netherlands

The importance of LCA tool DuboCalc within RWS is growing and the approach has been broadened to link with circular economy goals. RWS are developing a strategy to work towards zero carbon emissions and are produce an integrated approach related to asset management, innovation and agreements with suppliers and other purchasers and governments.

RWS are currently working on including climate change adaptation in replacement and renewal projects and on including it in service level agreements (maintenance).

Recommendations

- Set a long term-goal for where you would like to be in terms of implementing your selected sustainable procurement approach
- Establish interim goals, for example focusing on specific materials or carbon sources or types of projects.
- Regularly review the approach, including consulting suppliers and manufacturers.
- Keep moving forward, expanding and improving your approach, but slowly working with the industry and piloting changes before rolling them out more widely.

PART B: Procurement tool manual

11 Introduction and context of the tool

11.1 Objectives of the procurement tool

The Procurement Collaboration Tool provides NRAs with guidance and case studies related to embedding climate change in procurement and operational processes. The functional specification of this tool is based mainly on the stakeholder requirements identified at the DeTECToR workshop in Brussels near the start of the project.

The Procurement Collaboration Tool enhances the collaboration between NRAs and sharing of experience and good practice between NRAs. This exchange is vital to progression in this area. The collaboration platform enables NRAs access to a large knowledge database related to embedding climate change action into procurement processes.

The tool focuses on practical implementation and offer NRAs assistance in decision making processes. It may be necessary to consider the impact of procurement law and existing technical procedures on different procurement approaches.

There is a large variation in the level to which climate change is embedded in NRA procurement processes. Some NRAs are quite advanced in their thinking, whereas others have not considered it at all. There will be different levels of ambition in address climate change therefore one approach will not be suitable for all NRAs.

To use the DeTECToR Collaboration Tool user authentication is necessary. Each User has individual credentials (username and password) to confirm their identity, which are queried during the log-in process.

11.2 When to use it

Essentially, the tool provides easy access to the information about experience and good practice the area of procurement in context of climate change in one place. Thanks to easy navigation and advance search functions the user can navigate through sections to obtain relevant information on different topics. In its current state, the platform internal database contains strategic level information dealing with general approaches and specific examples from the pilot studies. It is up to future users to add their individual experiences and share these through the platform.

The database needs to be filled by additional information to be truly effective. It is important that NRAs at different stages of embedding climate change in procurement engage through the platform. NRAs with greater experience with embedding of climate change in procurement should share this with the community and can compare the effectiveness of their approach with others, and that those less advanced should highlight the areas where they need advice and explain the challenges they face. As the name of the tool says, this is a collaboration platform. This requires engagement on both sides.

11.3 Target users

The collaboration platform is aimed primary at the strategic decision level. The information provided in the collaboration can be considered when setting and implementing procurement policy. In some cases it could be beneficially to share pertinent information outside NRAs, for

example with politicians involved directly in the implementation of mitigation actions or responsible for implementation of climate change mitigation plans.

11.4 Development

The Procurement Collaboration Tool is a wiki-based tool to facilitate the exchange and collaboration of road administrations of different countries and to transfer knowledge. The main page structure can only be modified by an Administrator, but all users can add new topics or make changes in existing ones, upload images and insert external as well as internal links. However, it is not an open platform, but password-protected. All changes are traced and linked to the respective user to ensure the platform content is kept relevant and not misused.

Currently, the tool is hosted by the project and accessible via the DeTECToR webpage. The project consortium will discuss with PEB and CEDR the possibilities for linking the tool to the CEDR website or hosting it on the CEDR server.

12 Overview of tool and its functionality

The DeTECToR collaboration platform has been implemented as wiki based web application. The user can navigate thought the content or use the search function to find the requested information. The content pages are linked together, so the user can follow the links in order to open the next content page.

A registered user can easily edit the content page and add new content or change existing information. All changes are traced and can be reviewed by Content Administrator who can accept or revert the change.

The project has elaborated and implemented a Top Level Structure (TLS). The TLS corresponds to areas of action for embedding climate change mitigation and adaptation into procurement and NRA operations. Each TLS page was filled with initial content based on findings from the literature study and interviews with the pilot study NRAs. The initial TLS is described in chapter 1.

The main page of the collaboration tool has been structured according to TLS (see Figure 13).

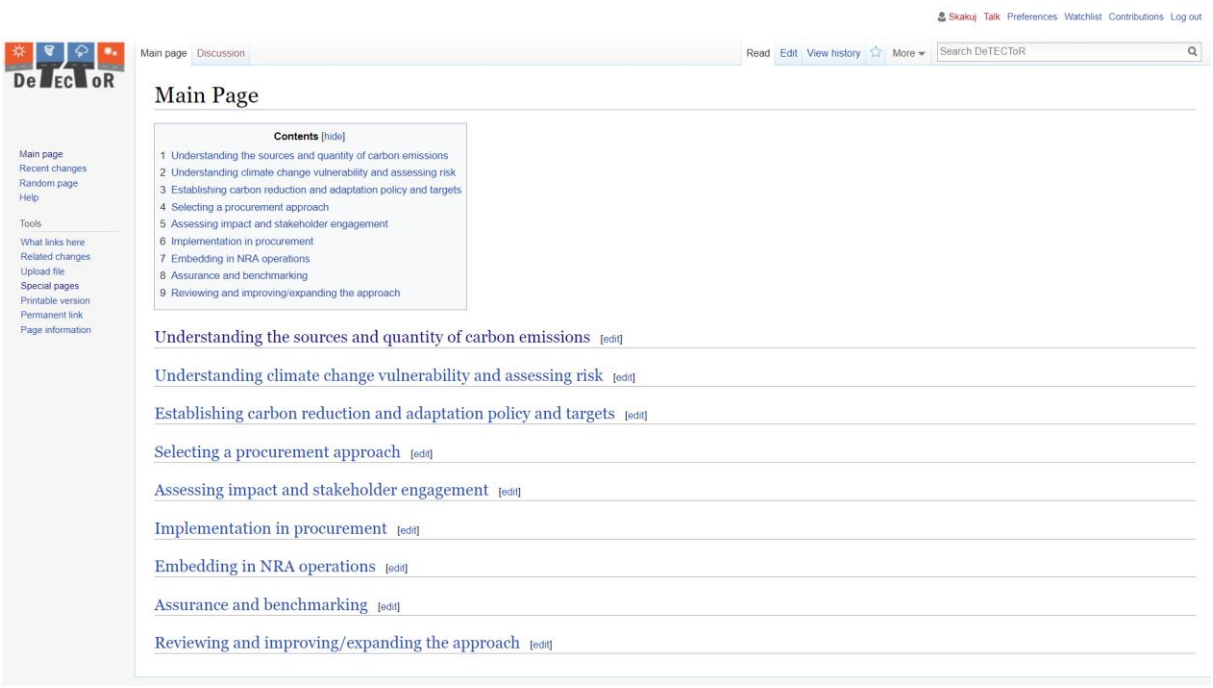


Figure 13 Main page of the procurement collaboration tool

13 Step-by-step guide to using the tool

In the following section a short guide to using the DeTECToR collaboration tool is provided. In order to have more extensive background information how to work with MediaWiki please follow the link: https://www.mediawiki.org/wiki/Help:Contents which leads to the official help pages of MediaWiki.

13.1 Start the application

The DeTECToR collaboration tool is implemented as a web application and runs in a typical web browser. In order to run the application the user needs to enter the URL into web browser. During the project, the tool was deployed on the server of one of the members of the project consortium. Following the completion of the project, it is assumed that CEDR will host the tool and provide access to CEDR members. At the time of writing to run the application the following URL needs to be entered in web browser: http://detector.heller-ig.de.

To enter the application, the user needs to enter their user name and password (see Figure 14). The credentials are obtained from the administrators who are responsible for the deployment and hosting of the application.

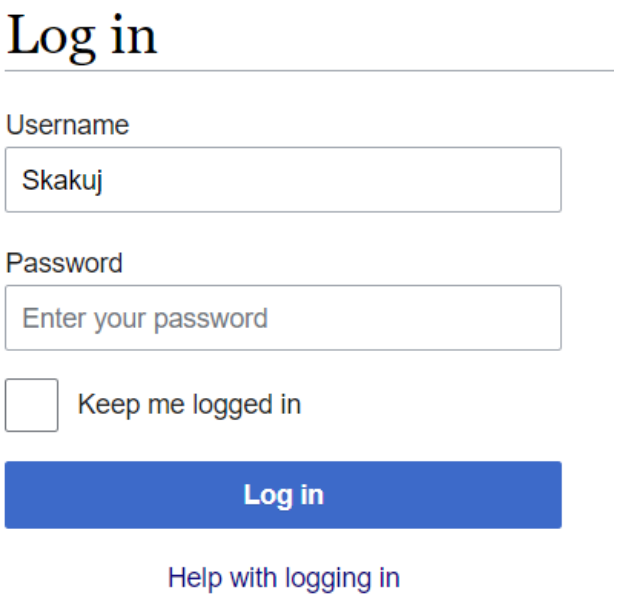


Figure 14: Login dialogue

After successful login, the main page with TLS will be shown (see Figure 13). By clicking on the interactive label, the corresponding content will be displayed in the window.

13.2 Search and navigation though content

The search function is located in right upper corner of the page.

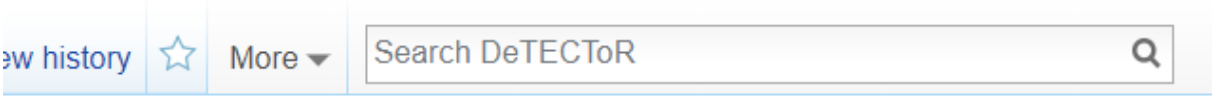


Figure 15: Search function

The searched phrase should be entered into this field. By pressing on enter on the keyboard, all pages which contains searched phrase will be listed (see Figure 16).

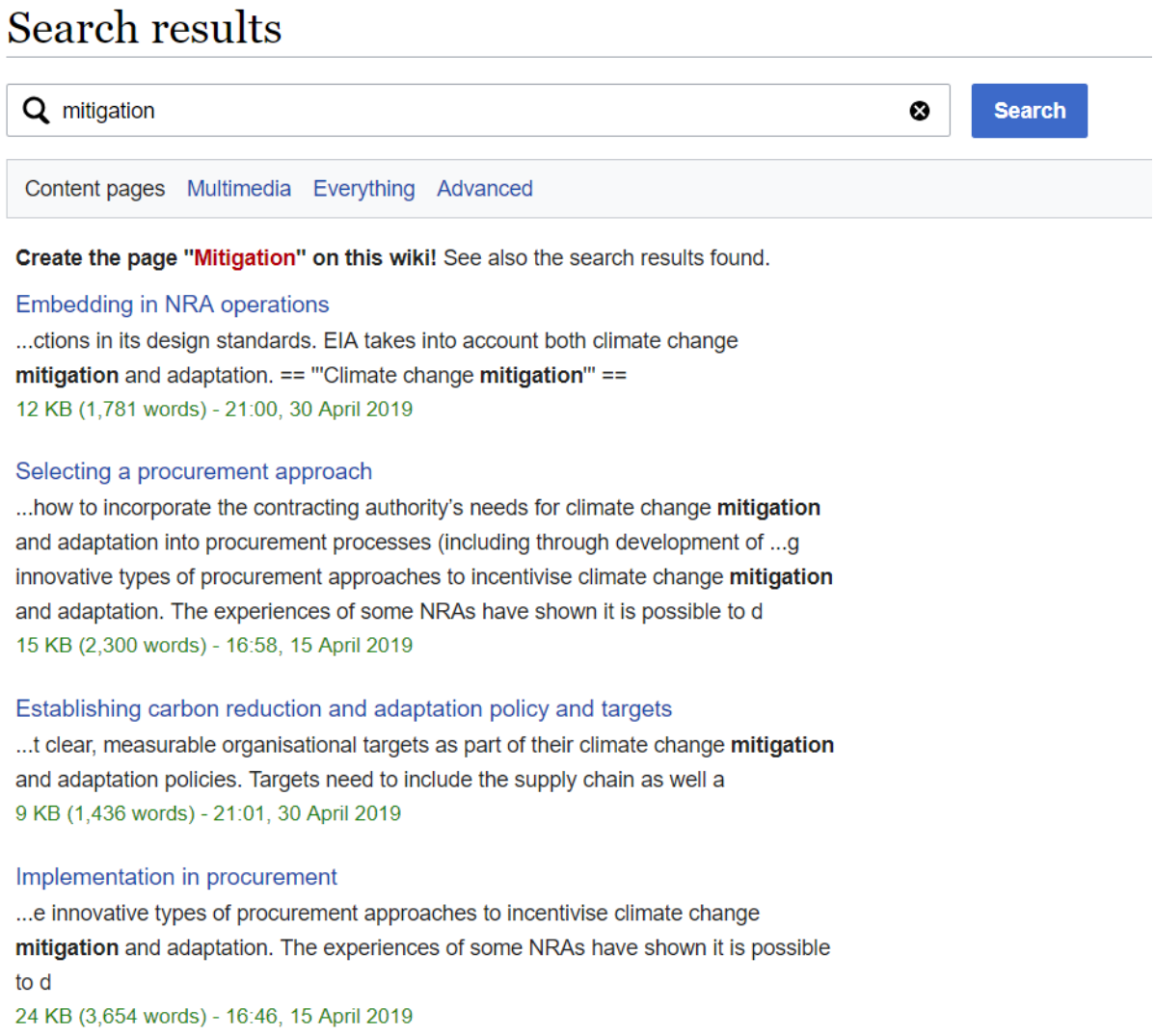


Figure 16: Search results for phrase "mitigation"

In the example presented in **Figure 16** four pages were found where the phrase "mitigation" occurs in the content of the page. Additional information like the size of the content page and

the date of the last change are presented. To open the requested content the interactive label with title of the page should be clicked. The content will be displayed in the window.

13.3 Editing pages

In order to edit a content page the “Edit” function located in the top of the page should be used (see **Figure 17**).

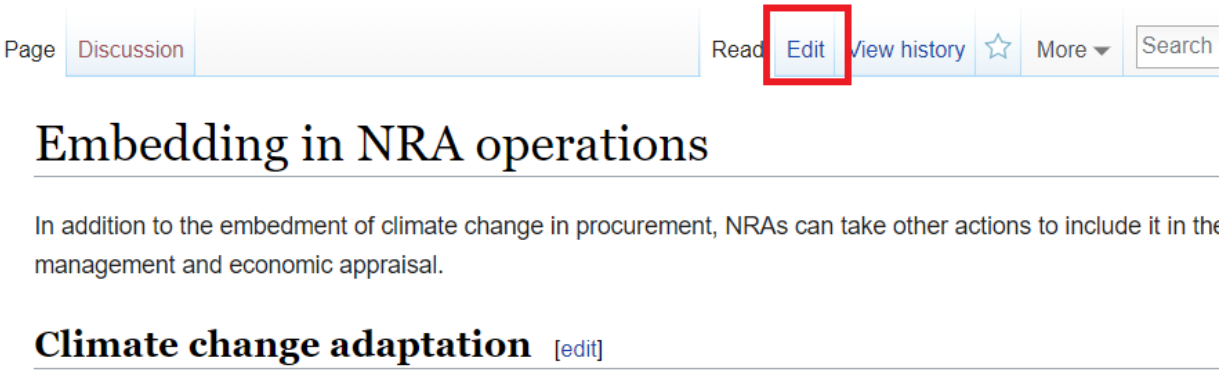


Figure 17: Editing function

After usage of the editing function, the content will be opened in build-in editor, where the content of the page can be changed (see Figure 18).

It is recommended that the user checks the page preview, before saving the changes.

By clicking on the label “Editing help” a new page with additional information on page editing will be displayed (in a separate window).

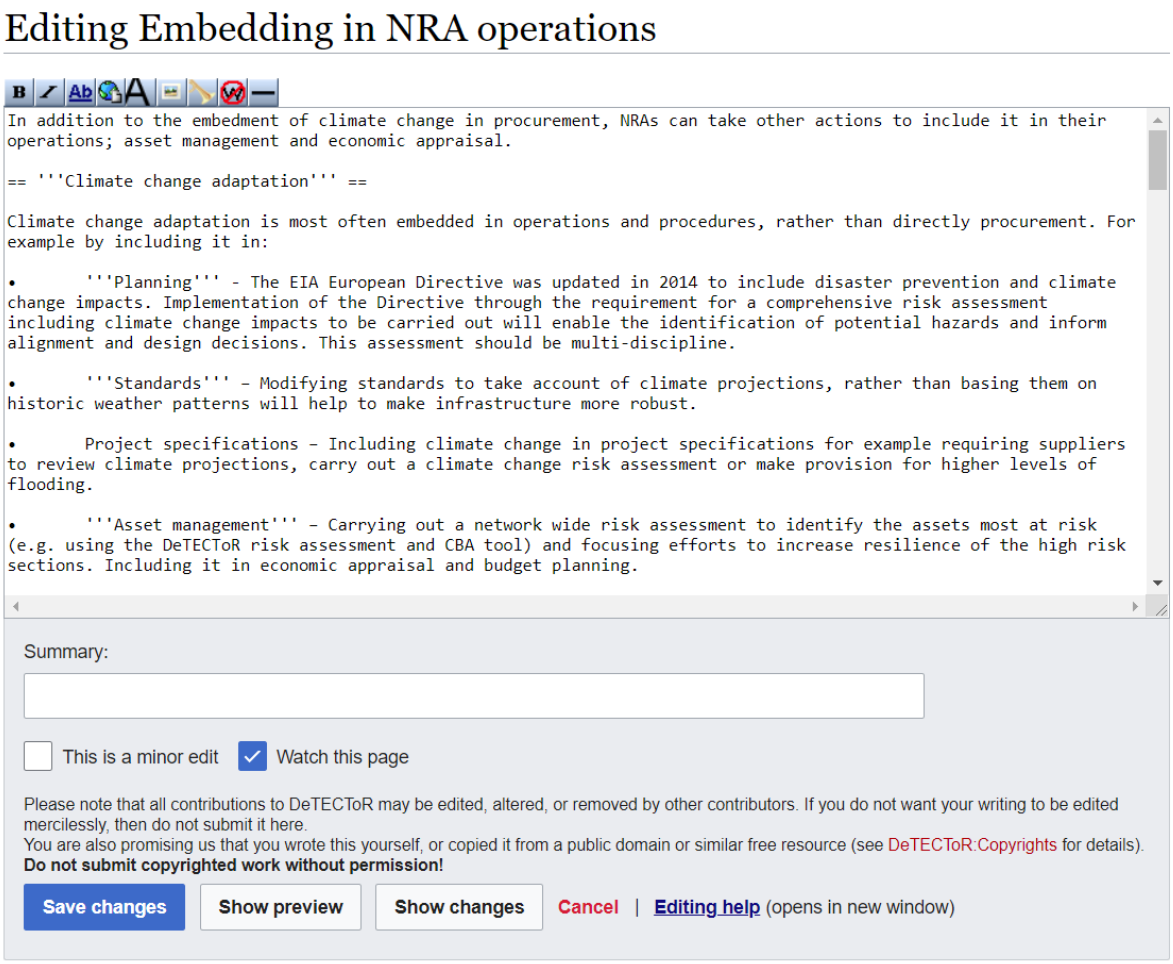


Figure 18: Build-in editor

See Section 14 for examples from the pilot studies of how to use the editor to amend and add new content.

13.4 Starting a new page

There are several ways to create a new page. The easiest way is to create link to a page which doesn't exists yet. Such link will be coloured red (see **Figure 19**).

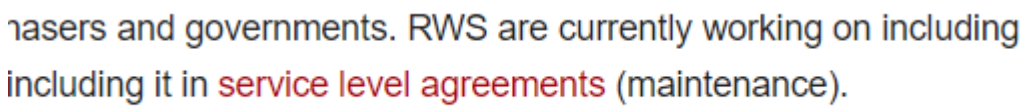


Figure 19: Link to the page which doesn't exist yet are coloured red

By clicking on read link, the build-in editor for the new page will be opened and new content can be typed.

A second method of creating a new page is through the search function. When a searched phrase does not exist as a page, an option to create a new page for searched phrase will be offered (see **Figure 20**).

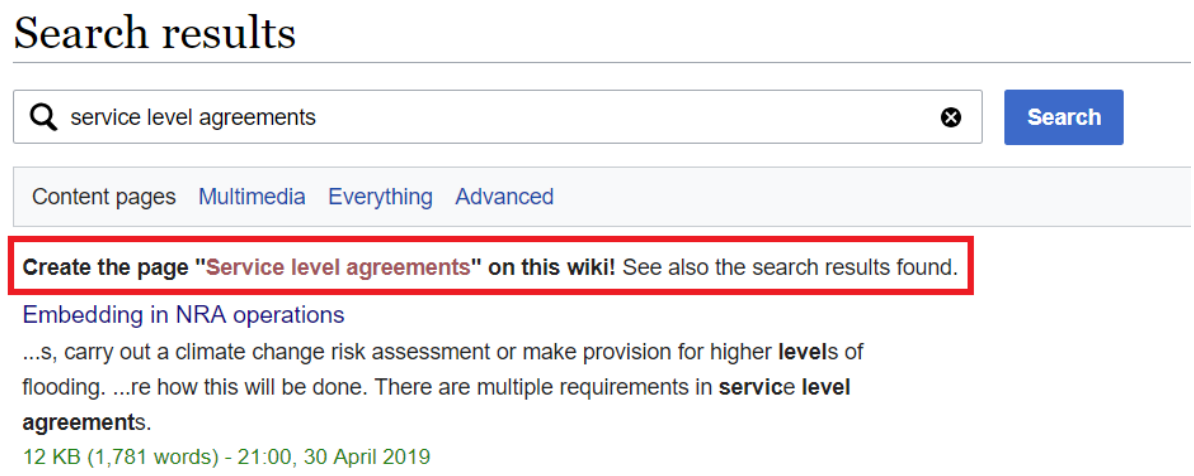


Figure 20: Adding new page by search results

By clicking on the red label, build-in editor for new age will be opened automatically.

A third method of creating a new page is using the URL of the DeTECToR collaboration tool. The name of the page is a part of the URL e.g. following URL
http://detector.heller-ig.de/index.php?title=Embedding_in_NRA_operations
refers to page “Embedding in NRA operations”.

To start a new page, the page name should be adjusted as a part of URL, e.g. to start new page for “Service level agreements” following URL
http://detector.heller-ig.de/index.php?title=Service_level_agreements
needs to be put in web browser.

One of offered options will be the function to create a new page (see **Figure 21**).

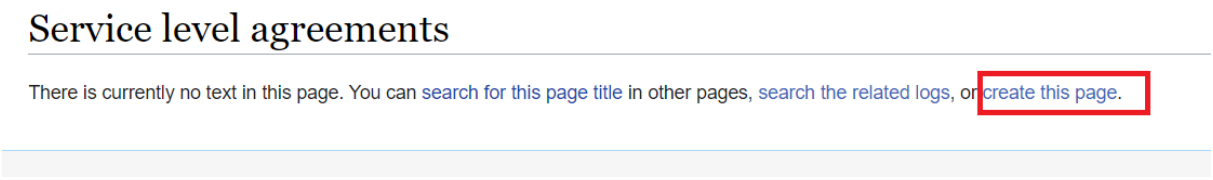


Figure 21: Starting a new page by URL

13.5 Revision history

The revision history of a page is viewed by clicking on the "View history" tab (see **Figure 22**).

Figure 22: Function to view the revision history for the page

The revision history of the page gives an overview about all saved editing operation. It offers function to see what has been changed, to compare to versions and to revert the edition operation.

Figure 23: Revision history of a page

14 Examples of editing page content

The top level structure, which was agreed with the PEB, consists of the following sections:

1. Understanding the sources and quantity of carbon emissions
2. Understanding climate change vulnerability and assessing risk
3. Establishing carbon reduction and adaptation policy and targets
4. Selecting a procurement approach
5. Assessing impact and stakeholder engagement
6. Implementation in procurement
7. Embedding in NRA operations
8. Assurance and benchmarking
9. Reviewing and improving/expanding the approach

Each of the topics was filled with the relevant information collected during various the project activities such as the literature study of existing projects, stakeholder survey and pilot studies with the NRAs (Sweden, Netherlands, and Norway). Once clicking on each tab (1-9) the user is taken to another page (within the tool) where detailed information is provided. The user is free to view and search the existing content, but can also upload their own text, images, graphs and relevant data directly to the page. The selection and modification of different types of material is described in this section with relevant screen shots from the tool to provide an overview of the tool functionality.

14.1 Editing and formatting text

Editing the content of each of the listed topics grouped in 1-9 is performed by clicking on the "edit" button as depicted in **Figure 24**. This brings up the window shown in **Figure 25**.

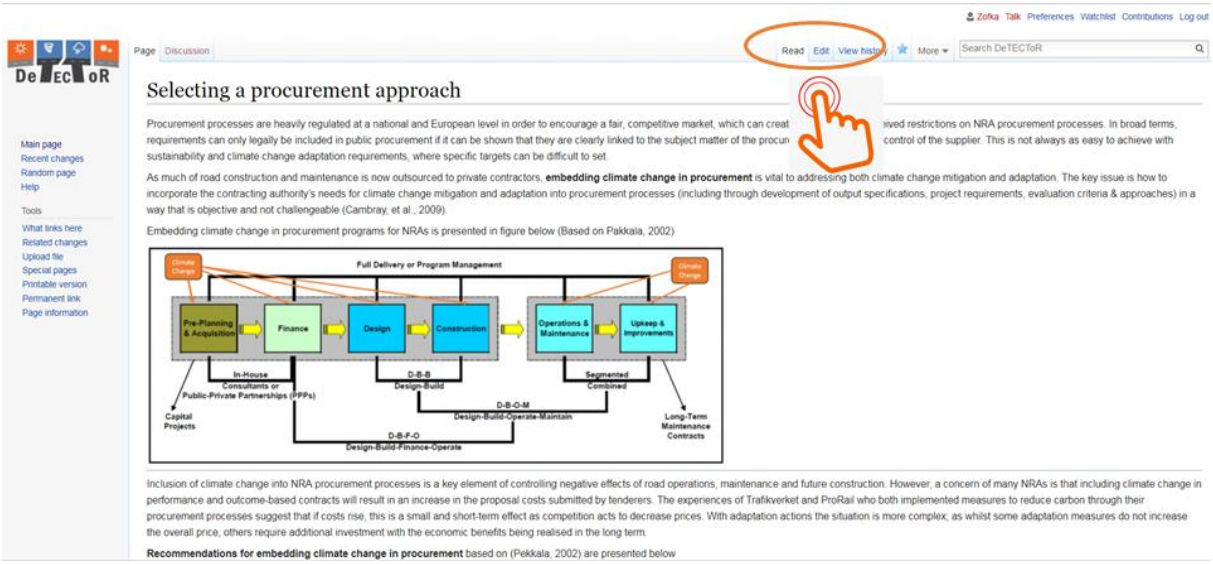


Figure 24: Editing page content

Here the user can click on "edit" button and amend existing text or add new material as shown in Figure 25.

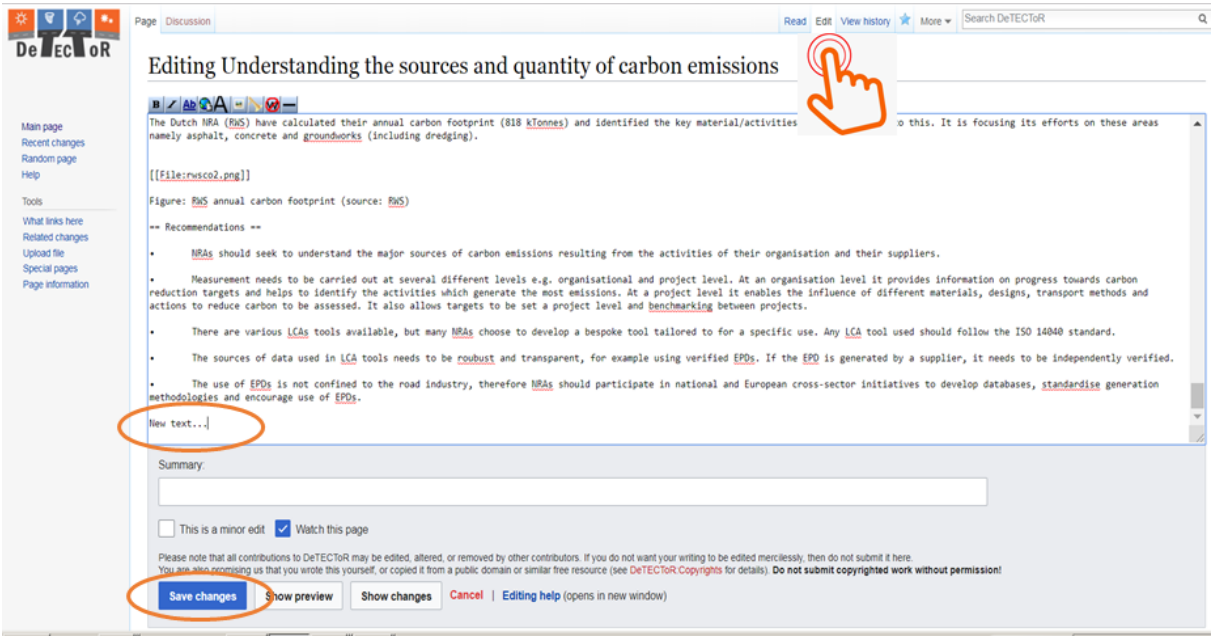


Figure 25: Adding new page content

In top right corner of the editing panel (see **Figure 26**) there are nine buttons for editing operations, consisting of:

- Three buttons for formatting text (bold, italics and underlined)
- A button for adding an internal link (to other pages or sections of the tool) or external hyperlink to other websites
- The button with capital “A” letter is called “level 2 headline”. This is used to divide the inserted text into different sections.
- The “embedded file” button with a picture icon, which is used to add images.
- A button for adding media files (trumpet icon)
- An ignore Wiki formatting button (crossed “W” letter)
- A button for adding a horizontal separation line.

Figure 26: Editing panel

Once the desired text is entered the user needs to click the “save changes” button on the bottom of the page to upload the changes into the tool.

Examples on how to use these features are explained below.

14.2 External Hyperlink

In order to insert an external hyperlink:

1. Insert new text or edit existing by clicking the “edit” button to the top right corner of the page as presented in **Figure 24**.

2. From the editing panel click add the external link icon (4th icon from the left with the globe symbol). (Text describing what an icon does appears when the user hovers over it with the mouse.)
3. The text "[http://www.example.com link title]" will appear in the editing window; insert the desired http address in the brackets, and the title of the link in the "title" as shown in the screenshot below (**Figure 27**).
4. Click "save changes" at the bottom of the page.

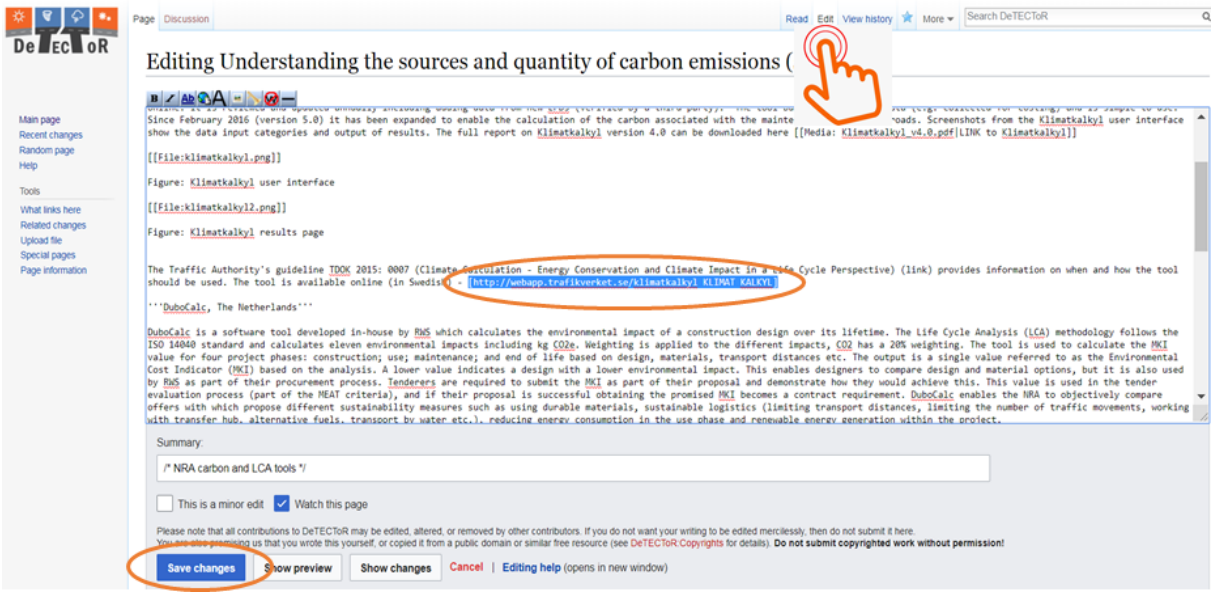


Figure 27: Adding an external hyperlink

The link can be viewed in the browser as depicted in **Figure 28**.

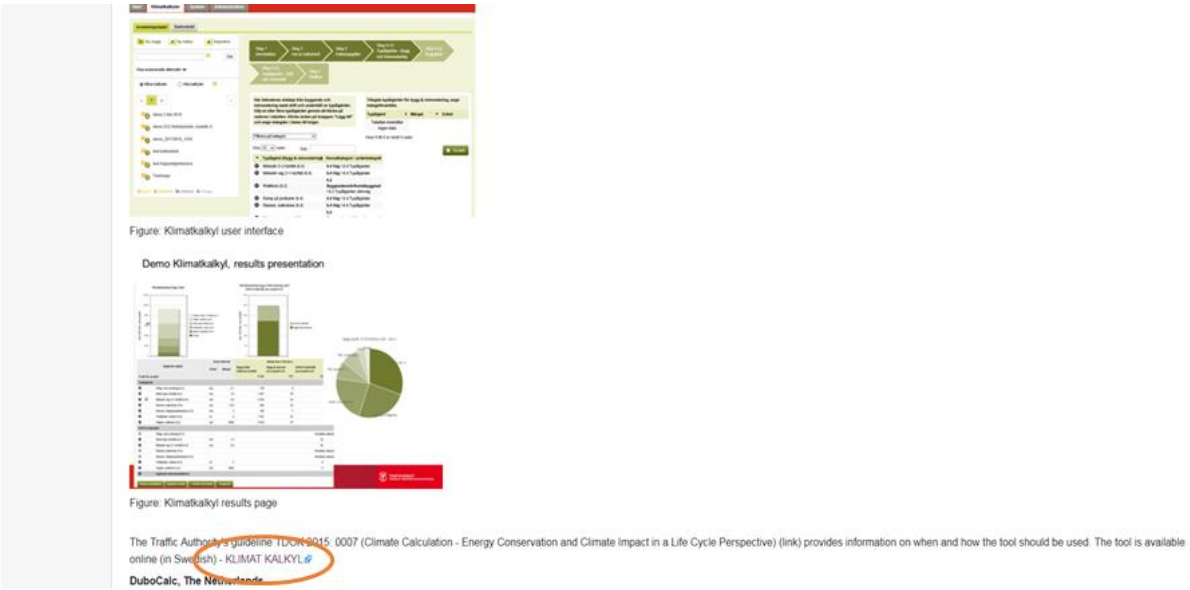


Figure 28: Adding an external hyperlink: final check

14.3 Insert image

An image can be inserted by:

1. Insert new text or edit existing by clicking the “edit” button to the top right corner of the page as presented in **Figure 24**.
2. From the editing panel click embedded file icon (icon with the picture symbol). (Text describing what an icon does appears when the user hovers over it with the mouse.)
3. The text “[File:Example.jpg]“ appears, then insert the name of the file in the brackets, and the extension (png or jpg) as shown in the screenshot below (**Figure 29**).
4. Click on “save changes”.
5. Click on “upload file” from the menu on the left side of the page as shown in **Figure 30** and follow the steps (choose an image file from those stored on your computer and upload).
6. The name of the uploaded file and the name under “[File:Example.jpg] in the edit file syntax needs to be the same.
7. View the image for a final check (**Figure 31**)

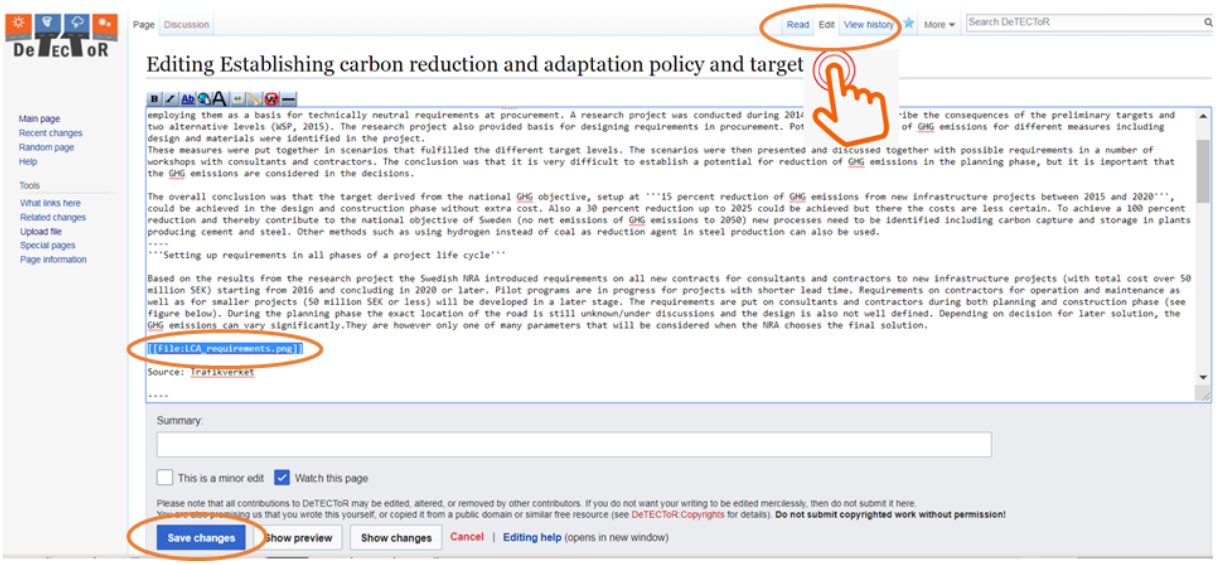


Figure 29: Inserting pictures/images

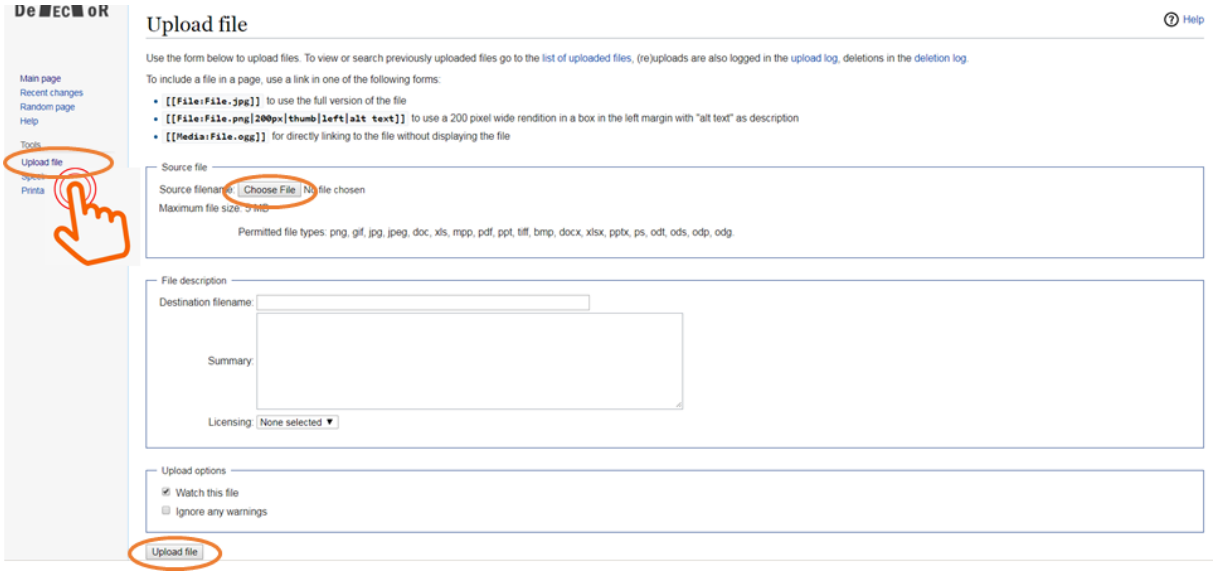


Figure 30: Uploading pictures/images

Figure 31: Uploading pictures/images: final check

14.4 Insert a PDF with external link

A pdf file (for example a research project summary sheet) can be inserted by:

1. Insert new text or edit existing by clicking the "edit" button to the top right corner of the page as presented in **Figure 24**.
2. From the editing panel click on the file link icon (3rd icon from the right with the trumpet symbol). (Text describing what an icon does appears when the user hovers over it with the mouse.)
3. The text "[[Media:Example.ogg/link title]]" appears in the editing window. Insert the desired file name in the brackets, and the extension "pdf" as shown in the screenshot below (**Figure 33**). Also the name of the link title needs to be completed. In this

example it is: [[Media: DeTECToR_Project_Summary_Sheet_CEREAL_final.pdf|LINK to project summary sheet]].

4. Click “save changes” at the bottom of the page.

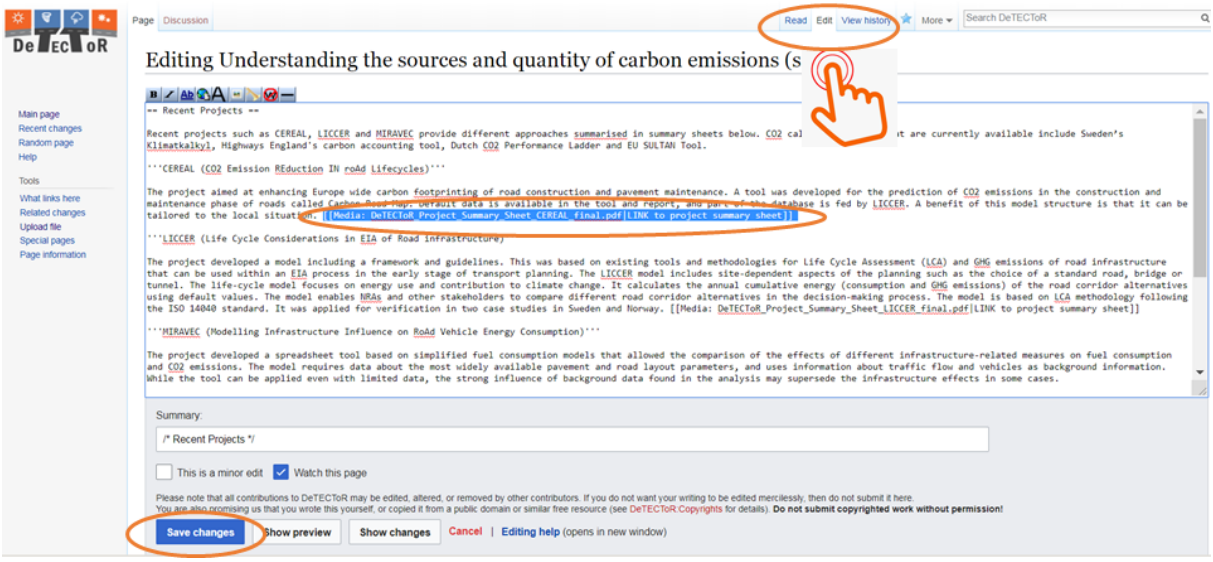


Figure 32: Inserting a pdf file with external link

5. The name of the uploaded pdf file and the name under “[Media:Example.jpg] in the edit file syntax needs to be the same.
6. View the image for a final check as shown in **Figure 33**.

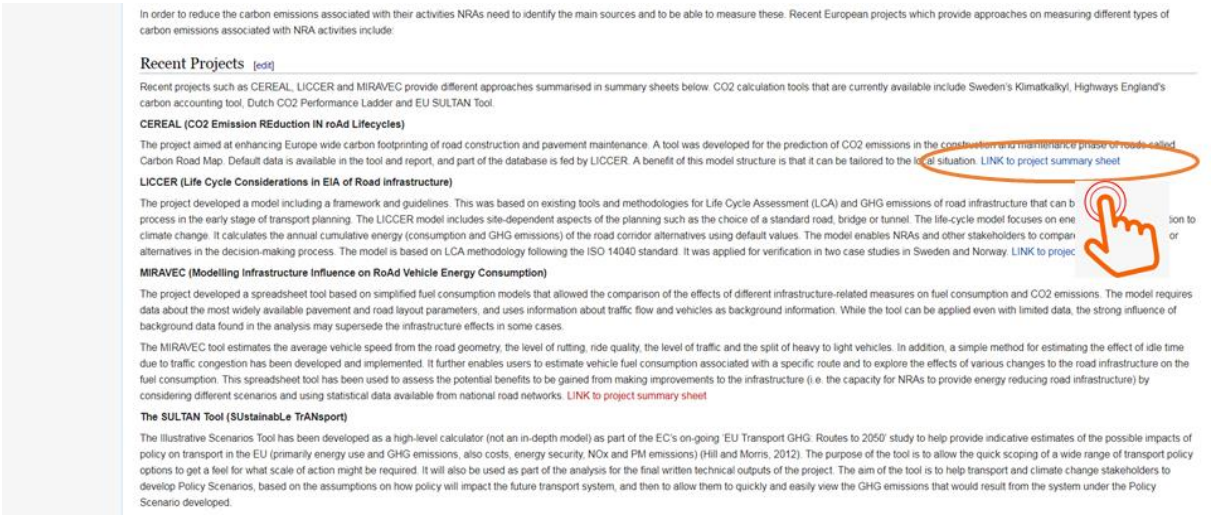


Figure 33: Inserting a pdf file with external link: final check

15 Acknowledgements

The research presented in this guidance document was carried out as part of the CEDR Transnational Road Research Programme Call 2015. The funding for the research was provided by the national road administrations of Germany, Netherlands, Ireland, Norway, Sweden and Austria.

References

AIRMIC, Alarm and IRM (2010) “A structured approach to Enterprise Risk Management (ERM) and the requirements of ISO 31000”, accessible at https://www.theirm.org/media/886062/ISO3100_doc.pdf

AECOM (2014) “Economic framework for analysis of climate change adaptation options – Framework specification”, accessible at https://www.environment.gov.au/system/files/resources/21810fe1-5333-420a-b1ae-6c45b8a14139/files/economic-framework-adaptation-options.pdf

Alfieri, L., Velasco, D. and Thielen, J. (2011) “Flash flood detection through a multi-stage probabilistic warning system for heavy precipitation”, Adv. Geosci. 29, p69-75, accessible at http://www.adv-geosci.net/29/69/2011/adgeo-29-69-2011.pdf

Altvater, S., de Block, D., Bouwma, I., Dworak, T., Freilh-Larsen, A., Gorlach, B., Hermeling, C., Klostermann, J., Konig, M., Leitner, M., Marinova, N., McCallum, S., Naumann, S., Osberghaus, D., Prutsch, A., Reif, C., van der Sandt, K., Swart, R. and Trolzsch, J. (2012) “Adaptation measures in the EU: Policies, costs and economic assessment”, Eco logic, Deliverable for project “Climate proofing of key EU policies – short term actions

Atkins (2013) “Economics of climate change adaptation and risks: Final report, Highways Agency”, July 2013

Barth, M. and Boriboonsomsin, K. (2009) “Traffic congestion and greenhouse gases”, accessible at http://www.uctc.net/access/35/access35_Traffic_Congestion_and_Grenhouse_Gases.pdf

Boshoff, L., Childs, R. and Roberts, L. (2009) “Guidelines for infrastructure asset management in local government 2006-2009”, Provincial and Local Government, Republic of South Africa, accessible at http://mig.cogta.gov.za/Content/Documents/Guidelines/MIG%20-%20IAM%20Guidelines%202006-2009.pdf

Cambridge Systematic Inc. (2009) “Moving cooler – An analysis of transportation strategies for reducing greenhouse gas emissions”, Executive summary accessible at https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/MovingCoolerExecSummaryULI.pdf

Cambray, A., Howcroft, A., Retana, J., Dowden, M., and Schellekens, G. (2009). Adapting to climate change: the role of public procurement. Greater London Authority, London, UK. http://climatelondon.org.uk/wp-content/uploads/2012/10/Adapting-to-climate-change-the-role-of-public-procurement.pdf

Cañavera Herrera (2016) “Roads to adaptation: Understanding decision-making for adaptation of road infrastructure to climate change”, Dissertation submitted for Degree of Masters of Research at the Department of Engineering, University of Cambridge

Chatterton, J., Viavattene, C., Morris, J., Penning-Rowsell, E. and Tapsell, S. (2010) “The costs of the summer 2007 floods in England”, Published by Environment Agency, accessible at http://nationalfloodforum.org.uk/wp-content/uploads/EA-Costs-of-Flooding.pdf

Chevreuil, M. and Jeannière, E. (2015) “ROADAPT, Roads for today, adapted for tomorrow – Guideline Part D, Socio-economic impacts analysis”, CEDR Call 2012: Road owners adapting to climate change, accessible at http://www.transport-research.info/sites/default/files/project/documents/ROADAPT_Part_D_guidelines_on_socioeconomic_impactassessment.pdf

ClimateXChange (2016) “Indicators BT22 landslide events affecting the road network and BT23 road closures due to landslides”, Indicators and trends, Monitoring climate change adaptation, Version 14/03/16, accessible at

http://www.climatexchange.org.uk/files/2914/7463/8756/BT2223_landslide_events__road_closures_due_to_landslides_branded.pdf

Danish Road Institute (2010) "Methods to predict and handle flooding on highways – The blue spot concept", Danish Road Institute, Report 181 – 2010, accessible at http://en.klimatilpasning.dk/media/297917/the_blue_spot_concept_report_181.pdf

Die Bundesregierung (2008) "Deutsche Anpassungsstrategie an den Klimawandel", vom Bundeskabinett am 17. Dezember 2008 beschlossen, accessible at http://www.bmub.bund.de/fileadmin/bmu-import/files/pdfs/allgemein/application/pdf/das_gesamt_bf.pdf

Dietz, S. (2016) "Cost-benefit analysis of climate change adaptation options for the Chignecto transportation corridor", Adaptation 2016, Aster Group

Doll, C., Kohler, J, Klug, S., Papanikolaou, A. and Mitsakis, V. (2012) "Deliverable 7 – WEATHER project summary and policy conclusions", WEATHER, accessible at http://www.weather-project.eu/weather/downloads/Deliverables/WEATHER-D7_fin.pdf

Doll, C., Kohler, J, Klug, S., Papanikolaou, A. and Mitsakis, V. (2012) "Deliverable 7 – WEATHER project summary and policy conclusions", WEATHER, accessible at http://www.weather-project.eu/weather/downloads/Deliverables/WEATHER-D7_fin.pdf

Dorée, A., van der Wal, G. and Boes, H. (2011) "Client leadership in sustainability: How the Dutch railway agency created CO2 awareness in the industry" In: Egbu, C. and Lou, E.C.W. (eds.) Procs 27th Annual ARCOM Conference, 5-7 September 2011, Bristol, UK, Association of Researchers in Construction Management, 685-694, available at http://www.arcom.ac.uk/-docs/proceedings/ar2011-0685-0694_Doree_vanderWal_Boes.pdf

Environment Agency (2012) "Thames Estuary 2100: Managing flood risk through London and the Thames Estuary", TE2100 Plan, November 2012

European Commission (2010) "COM2010 655 Final – Monitoring the CO2 emissions from new passenger cars in the EU: data for 2009.

European Commission (2011) "Green Public Procurement Transport – Technical Background Report", Report for the European Commission – DG-Environment by BRE, 2011, accessible at http://ec.europa.eu/environment/gpp/pdf/tbr/transport_tbr.pdf

European Commission (2017) "The EU Ecolabel", accessible at http://ec.europa.eu/environment/ecolabel/

Gransberg, Douglas D.; Senadheeka, Sanjaya P. (1999). "Design-Build Contract Award Methods for Transportation Projects," Journal of Transportation Engineering, ASCE, 125(6), 565-567

Greene, D. L. and Plotkin, S. E. (2011) "Reducing greenhouse gas emissions from U.S. Transportation", Prepared for the Pew Center on Global Climate Change, accessible at https://www.c2es.org/docUploads/reducing-transportation-ghg.pdf

Greenroads (2012) "Project handbook – Greenroads certification and assessment", August 2012, accessible at https://www.greenroads.org/files/244.pdf

Highways Agency (2011) "Highways Agency Climate Change Risk Assessment – August 2011", accessible at http://assets.highways.gov.uk/about-us/climate-change/HA_Climate_Change_Risk_Assessment_August_2011_v2.pdf

Highways Agency (nd). Resilience to flooding on the strategic road network, presentation by Mike Whitehead at a CIHT event. www.ciht.org.uk/download.cfm/docid/2A9731B3-45E1-4FA8-BC6B073FB72E1B06

Hill, N. and Morris, M. (2012) “EU Transport GHG: Routes to 2050 II – SULTAN illustrative scenario tool – User guide: 2012 update”, accessible at http://www.eutransportghg2050.eu/cms/assets/Uploads/Reports/EU-Transport-GHG-2050-II-Task-6-SULTAN-User-Guide-1Jun12.pdf

HM Treasury (2003) “The Green Book: Appraisal and evaluation of Central Government”, Treasury Guidance, London: TSO

HM Treasury and DEFRA (2009) “Accounting for the effects of climate change”, Supplementary Green Book Guidance, June 2009, accessible at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/191501/Accounting_for_the_effects_of_climate_change.pdf

International Institute for Applied Systems (IIASA), BC3 Basque Centre for Climate Change, Paul Watkiss Associates Ltd and University of Bath (2014) “A transparent overview and assessment of the relevant uncertainties for the main policy domains”, ECONADAPT, Deliverable 4.1

IPCC (2012) “Managing the risks of the extreme events and disasters to advance climate change adaptation: A special report of working groups I and II of the Intergovernmental Panel on Climate Change”, Cambridge, UK & New York, NY: Cambridge University Press

ISO 55000:2014, “Asset management – Overview, principles and terminology”

ISO 31000:2009, “Risk management – Principles and guidelines”

Lilley, P. (2012) “What is wrong with Stern? The failings of the Stern Review of the Economics of Climate Change”, The Global Warming Policy Foundation, GWPF Report 9, accessible at http://www.thegwpf.org/content/uploads/2012/10/Lilley-Stern_Rebuttal3.pdf

Mackie, P. and Worsley, T. (2013) “International comparisons of Transport Appraisal Practice – Overview Report”, Institute for Transport Studies, Faculty of Environment, University of Leeds

Matulla C., Namyslo, J., Andre, K., Chimani, B., Fuchs, F.(2014): Design guideline for a Climate Projection Data base and specific climate indices for Roads: CliPDaR. sciencesconf.org:tra2014:17592

Mediation Adaptation Platform (2013a) “Decision support methods for climate change adaptation, method overview: Summary of methods and case study examples form the MEDIATION project”, Technical Policy Briefing Note 1

Mediation Adaptation Platform (2013b) “Decision support methods for climate change adaptation, cost-effectiveness analysis: Summary of methods and case study examples form the MEDIATION project”, Technical Policy Briefing Note 2

Mediation Adaptation Platform (2013c) “Decision support methods for climate change adaptation, multi-criteria analysis: Summary of methods and case study examples form the MEDIATION project”, Technical Policy Briefing Note 6

Mediation Adaptation Platform (2013d) “Decision support methods for climate change adaptation, real options analysis: Summary of methods and case study examples form the MEDIATION project”, Technical Policy Briefing Note 4

Michigan Department of Transportation (2015) “MDOT Strategic Plan”, accessible at http://www.michigan.gov/documents/mdot/MDOT_mission_vision_and_goals_2_375168_7.pdf

NSW Government Asset Management Committee (GAMC) (1991) “Total Asset Management Manual”, accessible at http://lgam.wikidot.com/manual)

Pakkala P., (2002) Innovative Project Delivery Methods for Infrastructure An International Perspective, Finish Road Enterprise. alk.tiehallinto.fi/julkaisut/pdf/pakkalae5.pdf
Palmer, D. (2013) "The economic impacts of landslide and other climate driven events – Indirect consequential economic impacts", TRL Report.

Peeling, J. and Reeves, S. (2015) "USE-iT Deliverable 4.1 – Preliminary report on energy efficiency and carbon intensity based on investigation across modes and domains", Users, safety, security and energy in transport infrastructure project

Penning-Rowsell, E. C., Johnson, C., Tunstall, S., Tapsell, S., Morris, J., Chatterton, J. and Green, C. (2005) "The benefits of flood risk and coastal management: A manual of assessment techniques", London, Middlesex University

Ranzi, R., Mazzoleni, M., Milanesi, L. and Matjaz, M. (2011) "Critical review of non-structural measures for water-related risks", Report number: Deliverable D.3.1. of the EU 7FP Project KULTURisk - Knowledge-based approach to develop a culture of Risk prevention, 42 p.

Reeves S, Reid M and Sharpe J (2013) "The costs and benefits of increasing the resilience of rail geotechnic assets to climate change", TRL Published Project Report PPR672

Resilient Analytics (2014) "California Statewide Assessment Summary – Case Study 2014-7", accessible at http://www.resilient-analytics.com/content/case-studies/California_TRB_Analysis_Summary.pdf

Resilient Analytics (n.d.) "Product overview (IPSS-2)", accessible at http://www.resilient-analytics.com/content/publications/IPSS_RA%20Introduction_2014.pdf

RSSB (2016) "Tomorrow's Railway and Climate Change Adaptation: Final Report, Task 1: Economics of climate change adaptation appendices", accessible via SPARK

Scussolini, P., Kaprova, K., Melichar, J, Sainz de Murieta, E. and Kuik, O. (2016) "Description of adaptation options and their costs and benefits", ECONADAPT Deliverable D6.2, accessible at http://econadapt.eu/sites/default/files/docs/Deliverable%206-2%20Approved%20for%20publishing.pdf

Stern, H. (2006) "The economics of climate change", Vol. 30. London: HM Treasury, accessible at http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/sternreview_index.htm

Trafikverket (2016) "Klimatkalkyl version 4.0 – Model for calculating energy use and greenhouse gas emissions of transport infrastructure in a life cycle perspective"

UKCIP (2014) "BACLIAR vulnerability assessment", accessible at http://www.ukcip.org.uk/wizard/future-climate-vulnerability/bacliat/

UKCIP (2015) "Tools", accessible at http://www.ukcip.org.uk/wizard/
UNISDR (2009) "Terminology on Disaster Risk Reduction", accessible at http://www.unisdr.org/files/7817_UNISDRTerminologyEnglish.pdf

University of Exeter (2013) "SKAO and the future development of the CO2 performance ladder", accessible at http://business-school.exeter.ac.uk/media/universityofexeter/businessschool/documents/centres/cls/SKAO_case_study.pdf

Ward, J. (2015) "South West analyses resilience challenges", Transportation Professional, May 2015, accessible at http://www.ukroadsliaisongroup.org/en/utilities/document-summary.cfm?docid=F31FC119-3BC8-412B-A89F6B55DD526344

Watkiss, P. (2011) “The ClimateCost Project Final Report – Volume 1 Europe”, The impacts and economic costs of climate change in Europe and the costs and benefits of adaptation, Summary of results from the EC RTD ClimateCost Project, accessible at http://www.climatecost.cc/images/Policy_Brief_ClimateCost_Draft_Final_Summary_vs_4.pdf

Wayman, M., Mocanu, I., Peeling, J., Potter, J. and Rands, J. (2016) “REETS – Assessment of technologies with potential for energy reduction – Deliverable 2.1”, Realistic Energy Efficient Tunnel Solutions Project

WEATHER, n.d., “Weather extremes: Assessment of impacts on transport systems and hazards for European regions – Briefing Note”, accessible at http://www.weather-project.eu/weather/downloads/WEATHER-Briefing-Note-v01.pdf

West, B. H., McGill, R. N. and Sluder, S. (1999) “Development and validation of light-duty vehicle modal emissions and fuel consumption values for traffic models”, Oak Ridge National Laboratory, March 1999, accessible at https://ntl.bts.gov/lib/22000/22000/22019/PB99155137.pdf

Williams, G. (n.d.) “Asset Management Standards. From PAS55 to ISO5500 – Where could this go?”, accessible at https://de.scribd.com/document/252748923/Asset-Management-Council-1106-PwC-Presentation-to-ISO-Hobart-20110929-V2

Winter, M. G., Shearer, B., Palmer, D., Peeling, D., Harmer, C. and Sharpe, J. (2012) “Assessment of the economic impacts of landslides and other climate-driven events: Final Report”, Prepared for Transport Scotland

World Bank, 2010. Introduction to greenhouse gas emissions in road construction and rehabilitation, Egis. http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwiI5MSVmKTSAhWBKMAKHYeqCl4QFggdMAA&url=http%3A%2F%2Fsiteresources.worldbank.org%2FINTEAPASTAE%2FResources%2FGHG-ExecSummary.pdf&usg=AFQjCNESVUT_Mx6NmMOUjLHSUo6QXCMoXg&sig2=05xP8N2BVcTl1nO6MbjlsA

World Road Association (2012) “*Managing Operational Risks in Road Operations*”, PIARC, TC C.3

World Road Association (2016) “Methodologies and Tools for Risk Assessment and Management Applied to Road Operations”, PIARC TC 1.5, Paris 2016