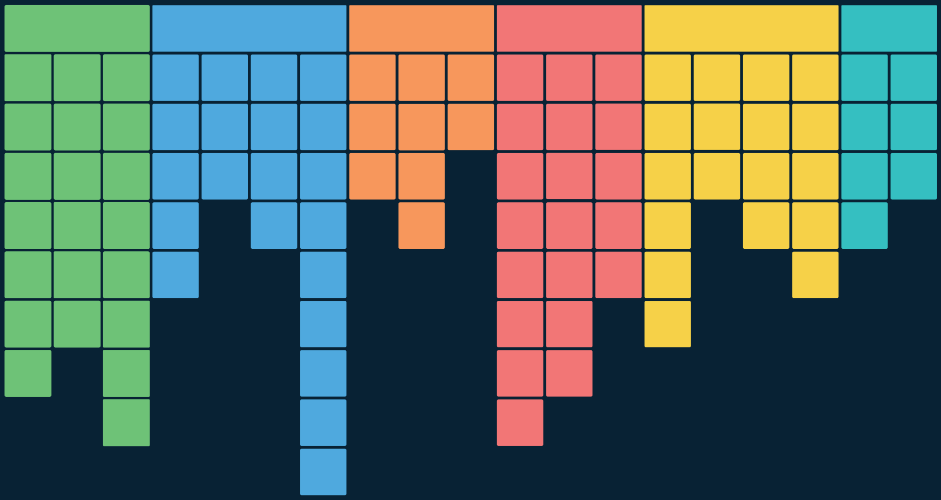
Standardising Climate Mitigation:

THE TRANSITION ELEMENT FRAMEWORK

An Open-Source Initiative To Structure And Codify IPCC Knowledge For Implementation Of Climate Action



Standardising Climate Mitigation:

THE TRANSITION ELEMENT FRAMEWORK

An Open-Source Initiative To Structure And Codify IPCC Knowledge For Implementation Of Climate Action

Abstract

The fight against climate change demands a standardised and systematic approach to defining and implementing mitigation strategies. This paper introduces the Transition Element Framework (TEF) as a way to bring clarity and coherence to the complex field of climate mitigation, where ambiguous terminology and inconsistent methodologies have hindered global efforts. The TEF is part of a larger open-source project designed to organise, define, and transform the Intergovernmental Panel on Climate Change (IPCC) knowledge into actionable planning information.

The TEF organises each IPCC Mitigation Option into a layered, mutually exclusive, and collectively exhaustive (MECE) structure, ensuring comprehensive coverage and avoiding overlap. It introduces the concept of “Activity Shifts” as the core element for achieving greenhouse gas (GHG) reductions, supported by measurable and assessable components such as interventions, attributes, and behavioural changes. As a result of the TEF, we have created the Periodic Table of Transition Elements, where each element represents an IPCC Mitigation Option.

With its ontology and taxonomy of climate mitigation activities, the TEF is a step towards standardisation and, hence, more effective comparison, analysis, and implementation of strategies across sectors and regions. Components of the TEF are being used in pursuit of a German Institute for Standardization (DIN) specification and subsequently a European Committee for Standardization (CEN) standard. The framework’s practical application is demonstrated through a technology platform rooted in collaborations with cities and regions, where it has facilitated advanced scenario planning, impact assessment, and the integration of IPCC guidelines into local climate action plans. The TEF’s flexibility and modularity allow it to adapt to diverse contexts, making it a valuable tool for policymakers and stakeholders at all levels. As an open-source initiative, the TEF will continue to evolve, expanding its library and enhancing climate action through data-informed insights and AI applications.

Authors: Tomer Shalit, Mark Dixon & Michael Bergöö
Editor: Lindsey Higgins, PhD
Layout & Graphics: Daresay
Stockholm, September 2024

How to cite this document: Shalit, T., Dixon, M. & Bergöö, M. (2024). *Standardising Climate Mitigation: The Transition Element Framework An Open-Source Initiative To Structure And Codify IPCC Knowledge For Implementation Of Climate Action.* ClimateView AB

This work © 2024 by ClimateView AB is licensed under Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International

Table of contents

INTRODUCTION

Language is ambiguous. One term can mean multiple things, and it's only possible to communicate if everyone is on the same definition of that term. When Carl Linnaeus developed his hierarchical classification system for botany, he brought order and consistency to the field, making it easier for scientists to study and understand plant diversity. This structured and systematic approach facilitated international collaboration by providing a common language for scientists worldwide, laying the groundwork for future discoveries and advancements in the field. Linnaeus's classification system revolutionised the study of natural history by providing a structured framework that was widely adopted and adapted over time.

Linnaeus's work in botany serves as a powerful analogy for understanding the significance of the Greenhouse Gas (GHG) Protocol in the fight against climate change. Just as Linnaeus's classification system standardised the study of plant diversity, enabling clear communication and collaboration across the scientific community, the GHG Protocol established a uniform framework for measuring and reporting emissions worldwide.

The global effort to establish decarbonisation targets truly began in 1997 with the signing of the Kyoto Protocol. Still, there were no universally accepted guidelines for measuring and reporting emissions at that time. Without standardised guidelines, it was challenging to compare emissions data across regions and industries, hindering efforts to assess and manage global emissions. Today, according to the World Resources Institute, the GHG Protocol has been directly referenced in voluntary and mandatory reporting standards around the world[1].

Within the context of climate change, this need for standardisation extends beyond emissions reporting. To align our global efforts and make meaningful progress toward decarbonisation, a standardised framework of climate Mitigation Options to guide action is required.

1. Aiuto, K., Huckins, S., & Momblanco, H. (2024, March 7). What Are Greenhouse Gas Accounting and Corporate Climate Disclosures? 6 Questions, Answered. World Resources Institute.

A common data structure for climate mitigation is a meaningful step toward systematically evaluating, comparing, and implementing approaches to reducing GHG emissions, ensuring that efforts are effective and aligned with global decarbonisation goals.

A comprehensive assessment of the state of climate science exists thanks to the work of the Intergovernmental Panel on Climate Change (IPCC). With the most recent Working Group III contributions to the IPCC Assessment Reports (AR4, AR5, and AR6) a vast knowledge base of climate change Mitigation Options has been compiled, laying the foundation for climate action. To make this body of work even more open and accessible, technology like artificial intelligence and data analytics offer the ideal companions for modernisation[2].

The creation of new technology platforms that provide interoperability with IPCC knowledge is advancing scenario planning and impact assessment, propelling climate action into a new era of collaboration and practicality. Open-source technology, in particular, has the potential to enable rapid innovation and problem-solving as contributions and knowledge can flow freely into the work. Climate change is a complex and urgent issue, and open-source technology ensures we leverage the collective intelligence and ingenuity of the global community to develop effective solutions.

2. De-Gol, A. J., Le Quéré, C., Smith, A. J., & Aubin Le Quéré, M. (2023). Broadening scientific engagement and inclusivity in IPCC reports through collaborative technology platforms. *npj Climate Action*, 2(1), 49

THE TRANSITION ELEMENT FRAMEWORK

This white paper introduces the Transition Element Framework (TEF), an open-source model designed to organise, define, and transform the IPCC's knowledge and information on climate mitigation into coherent and accessible planning information. The TEF is a systematic approach to codifying IPCC knowledge, ensuring that all relevant aspects of its Mitigation Options are covered. Through the TEF, each Mitigation Option is codified into what we call a Transition Element and organised into The Periodic Table of Transition Elements. This structure helps create a comprehensive understanding of the data and its interconnections, enables sector-wide and cross-sectoral collaboration, and ensures that future climate mitigation work can be easily integrated.

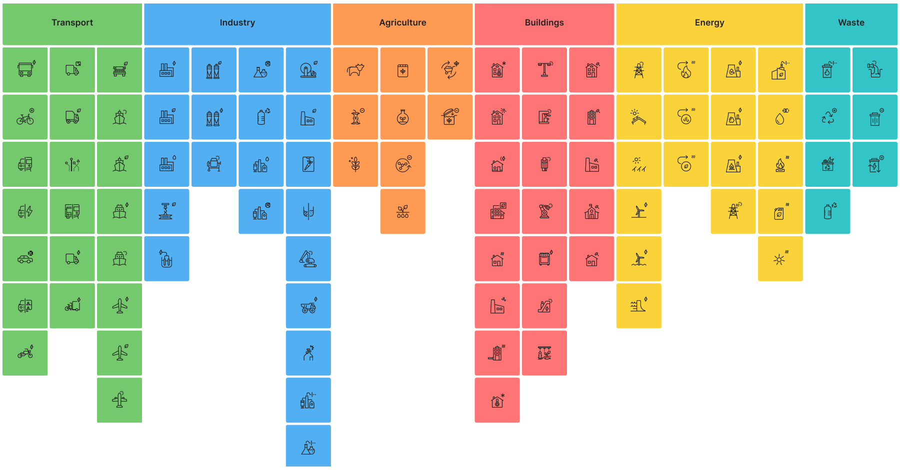


Figure 1. The Periodic Table of Transition Elements where each Transition Element represents an IPCC Mitigation Option.

Numerous modelling approaches to structuring data exist, each with unique strengths, and there can never be a single model that fits all needs. All models must balance being detailed enough to be useful and simple enough to be usable. The TEF provides a standardised framework that codifies Mitigation Options into Transition Elements, creating a common language for implementing and assessing climate strategies as well as for future research efforts. Essentially, the TEF is a model, logical structure, ontology, and taxonomy for what is inside an IPCC Mitigation Option.

An ontology and taxonomy

A taxonomy refers to a logical method of organising and classifying knowledge in a hierarchy of categories and subcategories based on common attributes. A taxonomy allows for easier navigation and increases the usability of data, and developing an ontology in addition to this adds versatility and depth. The ontology introduces context and relationships between the items, and groups of items, in the hierarchy. It goes beyond simple classification and frames knowledge and data in a way that makes it easier to understand, essentially giving a richer perspective with access to the entire picture rather than working with an isolated part of it.

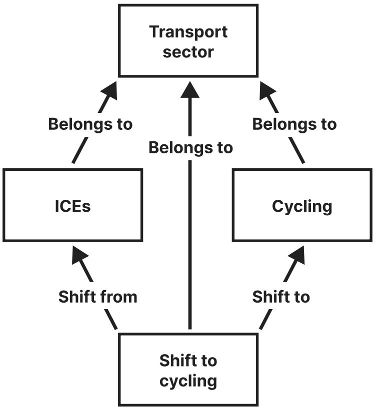


Figure 2. A simplified example of an ontology depicting the shift to cycling from internal combustion engines. The terms are defined and classified in the taxonomy, and the ontology defines how they are related.

This initiative's ontology and taxonomy refer to this structured framework, categorising, defining, and establishing the relationships between different pieces of data related to IPCC Mitigation Options. Here's what we mean by proposing a ontology and taxonomy:

- **Defining terms:** The framework defines key terms and concepts, such as what constitutes an "Intervention" or an "Activity." Establishing precise definitions ensures consistency and clarity in how these terms are used and understood.

- **Classification:** The framework categorises knowledge and information from an IPCC Mitigation Option into meaningful groups or classes, which enables a systematic arrangement. This helps identify and group similar data points, which aids in better analysis and understanding.

- **Relationships and interdependencies:** By defining how different concepts relate, the framework helps us understand the interdependencies between various factors involved in Mitigation Options. This can include the relationship between an intervention and its impact on greenhouse gas emissions or the relationship and interdependencies between different Mitigation Options.

We propose this detailed framework to provide the tools and structures necessary for effectively evaluating and implementing Mitigation Options. The framework also allows for the development of technology platforms that enable scenario planning, AI approaches, and other advanced data analytics. This initiative is designed to support policymakers at local, regional, and national levels, as well as other actors supporting these levels of government in their efforts to mitigate climate change through informed decision-making and efficient data use.

Core principles of the TEF

The TEF is built on three core principles: addressing emission sources, distinguishing means from objectives, and structuring efforts with clarity and completeness.

Principle 1: Addressing the source of emissions

Our society has been built on activities that produce greenhouse gas (GHG) emissions. These activities include, for example, driving cars, heating buildings by gas furnace, producing steel through smelting and raising cattle for meat.

> ***The main objective of mitigation is fundamentally about shifting high carbon emitting activities into lower ones.***

The IPCC has categorised and defined a method for calculating emissions from these activities in its guidelines, which can be used to assess the impact of transforming them to lower-carbon alternatives. Therefore, using these guidelines ensures standardised and accurate measurement of GHG emissions, aiding in the assessment and implementation of mitigation efforts.

Related to this principle, we are introducing Activity Shifts, a classification that encapsulates and describes all different ways to transform activities, as outlined by the IPCC Mitigation Options.

Principle 2: Distinguishing between means and objectives

When defining mitigation efforts, it is crucial to separate the means (such as individual interventions) from the objectives (the shift from high to low-emission activities). This separation is important because it ensures clarity in planning and implementation, allows for better assessment and measurement of progress, and prevents confusion between the actions and the ultimate goals.

> ***Separating means from objectives clarifies the path to achieving effective and measurable impact.***

For instance, it's often not possible for policymakers to carry out the transformation directly—a reality that many officials will be familiar with. People cannot easily be forced to change the way they commute, for example, but many can be swayed in the right direction through carefully planned interventions that modify the built and/or socio-economic environment of a municipality, region, or nation[3].

By establishing this principle, we ensure that all actions are aligned with the overarching objective of reducing GHG emissions through effective transformation of activities.

Principle 3: Applying MECE to structure clear and distinct layers and categories

The MECE principle[4]—Mutually Exclusive, Collectively Exhaustive—is vital for structured analysis and planning. It ensures that complex systems are divided into clear, non-overlapping components that, together, cover every necessary aspect. By using this principle, we can:

- **Mutually Exclusive:** This ensures that each component or layer focuses on a unique aspect, avoiding any overlap. This prevents ambiguity, confusion, and redundancy.
- **Collectively Exhaustive:** Cover all aspects comprehensively, leaving no gaps in the analysis or planning. This thoroughness ensures a complete understanding and effective implementation of strategies.

In the Transition Element Framework (TEF), the MECE principle organises the layers that form the framework, ensuring each layer is distinct and collectively encompasses all necessary parts for effective climate mitigation.

> ***Applying MECE ensures that every aspect of the climate mitigation strategy is addressed without overlap or gaps, leading to more effective and organised implementation of solutions.***

[3] Evans, D., McMeekin, A., & Southerton, D. (2012). Sustainable consumption, behaviour change policies and theories of practice. *The habits of consumption*, 113-129.

[4] Minto, B. (1987). *The Pyramid Principle: Logic in Writing and Thinking* (3rd ed.). London: Minto International.

OUTCOME LOGIC

The core of every Mitigation Option is ultimately centred on a shift of activity. Without a change in the activity, we cannot change the emissions associated with it, and therefore we aren't affecting the climate. To facilitate these transformations, an Outcome Logic is applied to systematically explore all possible aspects of reaching a mitigation objective. This systematic reasoning enables the implementation of the Mitigation Option and ultimately achieves the desired outcomes and impacts.

The Outcome Logic proposed as the starting point for this framework shows that reaching a particular outcome requires planners to identify the societal transition they wish to carry out. The Activity Shifts leading to the desired outcome are influenced by behavioural dynamics that are influenced by measurable properties of the environment of a municipality, region or nation, known as attributes, which are in turn influenced through decision-making processes. This logic can be seen in more detail in the example in Figure 1, which shows a shift from driving fossil-fueled cars to cycling. Starting with this defined objective allows for a more comprehensive understanding of the deterministic factors related to a successful outcome.

The term ”Outcomes” was chosen here in reference to the specific, measurable results that directly follow a shift of activity and to differentiate from impacts, which are more general qualitative effects. For instance, beyond reduced CO_2 emissions, the outcomes of increased cycling might be improved air quality (measured as particulate matter) and reduced healthcare costs (calculated by Euros saved in relation to reductions in respiratory illnesses and sedentary lifestyles). The impacts of increased cycling are more general and include aspects such as improved quality of life through greater urban livability and social equity. By focusing on outcomes in this framework, we can link the quantifiable results of mitigation efforts to the actions taken and assess their effectiveness, ensuring the framework remains precise and

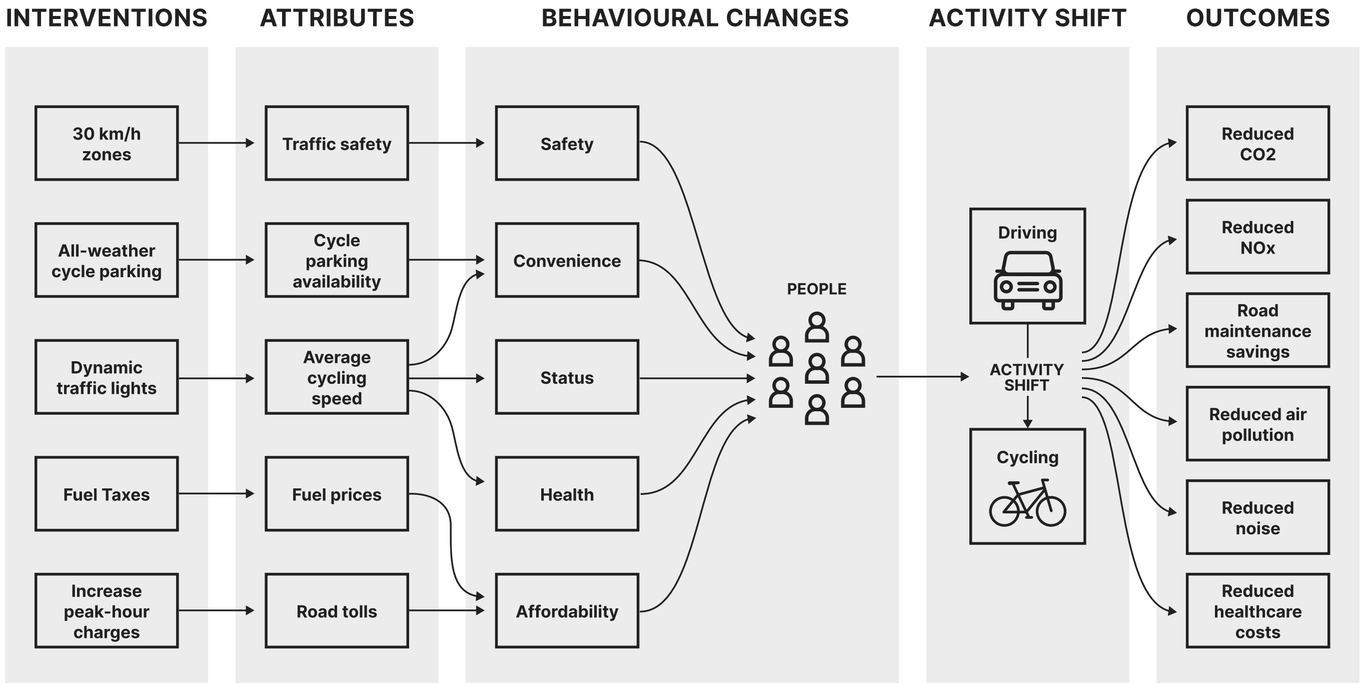


Figure 3. Outcome Logic for impact-oriented climate planning, using the example of shifting to cycling.

actionable, providing a clear understanding of both the direct results and the broader effects of mitigation efforts.

- **Interventions:** These represent decisions made at all levels of government—local, regional, and national—such as laws passed, investments decided upon, and strategies agreed upon. They are foundational directives that include measures like establishing 30 km/h zones, implementing all-weather cycle parking, installing dynamic traffic lights, imposing fuel taxes, and increasing peak-hour charges.

- **Attributes:** These are tangible, observable outcomes of interventions. They include measurable elements such as traffic safety, cycle parking availability, average cycling speed, fuel prices, and road tolls. These characteristics reflect the implementation of interventions.

- **Behavioural Changes:** The change in practices by the population (or parts of the population) whose behaviour is influenced by the perceptions formed from the attributes. How the city's population perceives these attributes, which can encourage or discourage different behaviours, varying across different demographics. It includes aspects such as safety, convenience, status, health, and affordability.

- **Activity Shift:** The objective of the Mitigation Option is defined by actual changes in physical activity, such as the shift from driving fossil fuel vehicles to cycling and walking. This represents the core elements of the transition.

- **Outcomes:** These calculate the results of the Activity Shift to understand their impact. Outcomes include reduced CO_2 emissions, reduced NO_x emissions, road maintenance savings, reduced air pollution, and reduced noise.

Here, an intervention is the result of a formal decision that leads to a change in attributes of a municipality, region or nation. A population's perception of these changed attributes will encourage or discourage different behaviour changes, and a transition from one activity to another over time (defined as an Activity Shift) will lead to one or more outcomes in terms of carbon abatement and other co-benefits.

Each of these layers can be further broken down into more detailed sub-layers. For instance, various scientific models describe behavioural change and extensive research data on city characteristics and attributes that influence behaviour. This layered approach allows us to delve deeper into specific models and data while keeping the overall framework at a usable level of abstraction.

MEASURABILITY AND ASSESSMENT

A key aspect of this framework is its ability to evaluate the entire pathway from interventions to outcomes, capturing how each layer influences the next through an interconnected sequence of interactions. The TEF is structured to measure what occurs within each layer and assess the cause-and-effect relationships that link these layers, enabling a comprehensive understanding of how interventions ultimately lead to outcomes.

Measurement of Layers vs. Assessment of Interactions

Within each layer, some aspects can be measured directly and quantitatively, while others are more complex and require descriptive analysis to capture their nuance and broader context. For example, interventions like the decision to build cycle paths or implement parking fees can be measured precisely because they are concrete actions while determining how the public perceives these actions is less straightforward. Still, assessing how one layer affects the next is a critical task, as these interactions will directly influence the progression of the Outcome Logic.

Quantitative vs. Qualitative Assessments of Interactions

- **Quantitative Assessments:** Some interactions, such as how Activity Shifts influence outcomes (e.g., increased cycling reducing CO_2 emissions), can be assessed with high confidence using established models and observable data. These quantitative assessments provide a clear, data-informed understanding of how specific changes lead to measurable effects.

- **Qualitative Assessments:** Other interactions, particularly those involving the Behavioral Change layer, require a qualitative approach due to the complexity of human perceptions and actions. For instance, assessing how changes in attributes (like increased bike lanes) influence public perceptions and drive behaviour involves subjective judgments and contextual understanding that are harder to quantify. These assessments are usually made across a portfolio of interventions, focusing on how they interact and work in tandem.

These interactions are designed to be clear and logical, ensuring the flow of information and influence between layers is smooth and understandable. This approach mirrors principles of abstraction often used in software engineering, where different system components must interact seamlessly through clear interfaces. By defining these interfaces, we ensure that the layers work together coherently, even as we explore each layer in greater detail.

While achieving perfect accuracy in predicting outcomes is inherently impossible, the strength of our approach lies in understanding and clearly communicating how assessments are made. By combining qualitative and quantitative methods, we not only provide a more robust basis for decision-making but also make our reasoning explicit and open to improvement. This transparency allows us to better evaluate the confidence behind each assessment and refine our approach over time as more data, comparisons, and real-world experiences—such as how similar changes affect behaviour in other cities—become available.

The TEF's structured taxonomy and ontology support this adaptive process by providing a consistent framework for organising and comparing these assessments. By mapping the links between layers and embracing both qualitative and quantitative approaches, we create a clear, practical, and evolving understanding of how different aspects of climate planning work together, enhancing the overall effectiveness of our strategies.

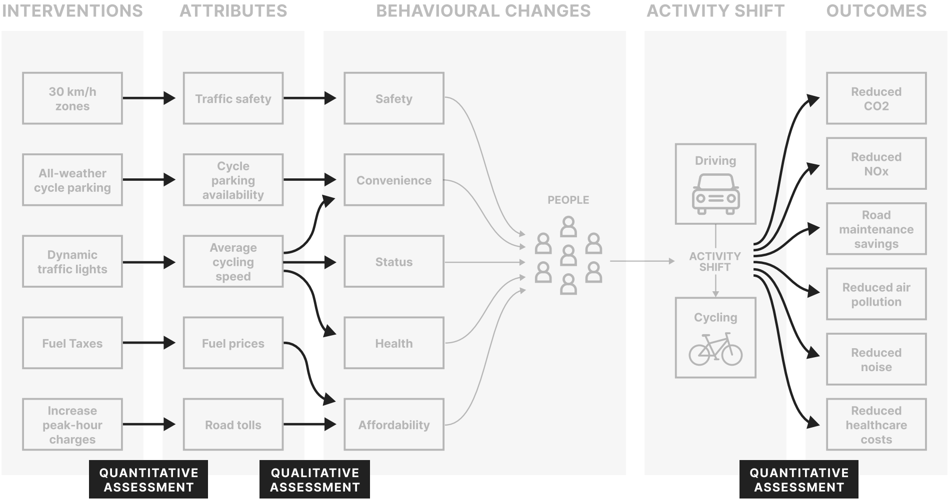


Figure 4. The TEF supports the evaluation of the entire pathway from interventions to outcomes, measuring each layer and assessing how one interfaces with the next.

THE FIVE LAYERS OF OUTCOME LOGIC

The TEF offers a clear and structured method for understanding and implementing Mitigation Options as described by the IPCC. The framework is designed to define Mitigation Options with as few layers as possible while encompassing all necessary elements from decisions to the desired outcomes. This ensures completeness and clarity. Furthermore, the framework's relevance spans all levels of governance, from municipalities to regional and national authorities, enhancing the practical application and impact of the IPCC's Mitigation Options.

To recall, each IPCC Mitigation Option is based on first principles and a physics-based perspective. This involves detailing the change in energy and resource usage that the Mitigation Option provides. The key objective of every Mitigation Option is to transition high-carbon activities towards lower-carbon activities. By achieving this objective, municipalities, regions and nations can realise the desired outcome of reduced GHG emissions and other environmental, economic and social benefits.

The core of the five layer model is the Activity Shift. Our definition of activities broadly matches the IPCC's definition. However, we have developed a standardised approach to describe an activity in its components: Operations, Work, Resources, Emissions, and Stock. This homogeneous pattern ensures consistency and clarity. By providing this pattern, we create possibilities for interconnections, enabling a more cohesive understanding and application of mitigation strategies.

Interventions

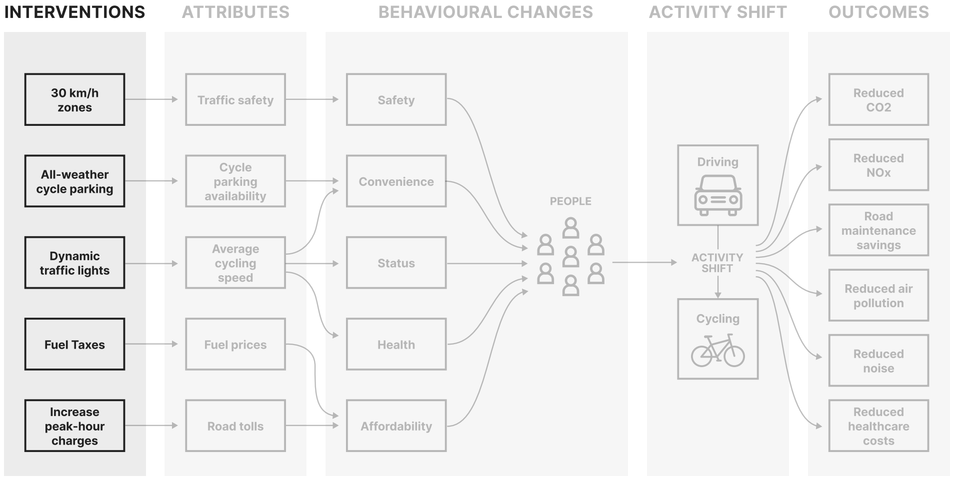


Figure 5. Interventions are strategic actions taken at various government levels to drive desired Activity Shifts and achieve climate mitigation outcomes.

To achieve the desired Activity Shifts, specific Interventions must be implemented. Interventions are the result of decisions and taken at all levels of government—local, regional, and national. These include passing laws, making investments, and agreeing on strategies. Interventions set the stage for changes in the local environment that can drive the desired Activity Shifts and can be classified across three dimensions:

1. **Category:** The type of intervention, such as tax, incentive, or infrastructure investment.
2. **Type:** How the intervention impacts the Mitigation Option.
3. **Scale:** The level at which the intervention is implemented.

Adopting the term "Interventions" ensures clarity and specificity in our framework. This term encapsulates the concept of deliberate actions taken to achieve defined objectives, differentiating it from broader or more ambiguous terms. It allows stakeholders to focus on the specific decisions and actions required to drive the desired Activity Shifts and mitigation outcomes.

TABLE 1: CATEGORIES OF INTERVENTIONS

Category	Description
Taxes and Fees	Financial charges imposed to influence behaviour and reduce emissions.
Incentives and Subsidies	Financial incentives to encourage specific behaviours or investments.
Regulations and Laws	Rules and regulations to mandate or restrict certain activities.
Programs and Initiatives	Projects or programs designed to achieve specific climate-related goals.
Infrastructure Investments	Investments in physical infrastructure to support mitigation efforts.

TABLE 2: TYPES OF INTERVENTIONS

Type	Description
Direct	Interventions with predictable, direct impacts on Activity Shifts, and thus emissions reduction and other outcomes.
Indirect	Interventions that influence city attributes, indirectly affecting behaviour and Activity Shifts.
Enabling	Interventions that provide opportunities or support for other interventions.

TABLE 3: SCALE OF INTERVENTIONS

Scale	Description
Local	Interventions implemented at the city or community level.
Regional	Interventions implemented at the state or regional level.
National	Interventions implemented at the national level.
International	Interventions implemented across multiple countries or globally.

These interventions influence attributes, which are measurable characteristics of the city or system that drive behaviour change.

Attributes

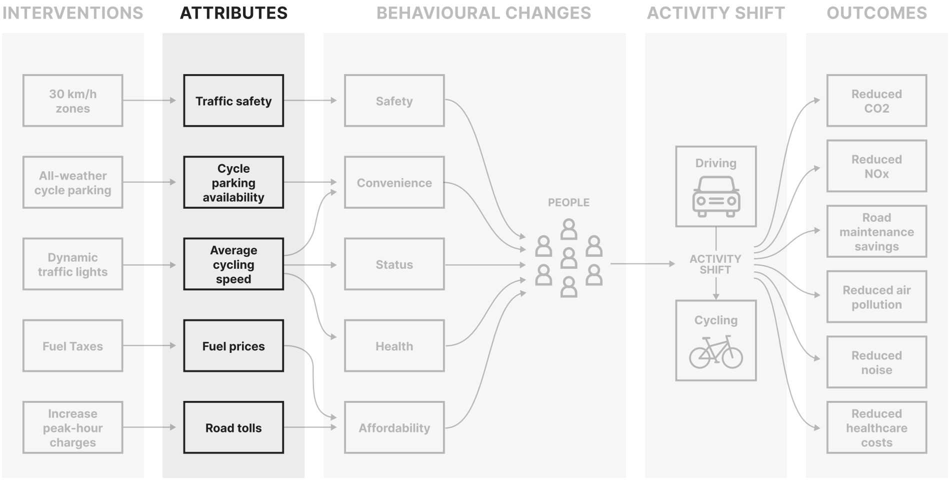


Figure 6. Attributes are measurable changes in the local environment resulting from interventions.

Interventions lead to changes in Attributes, which are the measurable properties of the local environment. Attributes can change over time and include elements such as traffic safety, availability of cycle parking, average cycling speed, fuel prices, and road tolls. These attributes are the direct outcomes of interventions and play a crucial role in shaping the environment in which people make decisions. Once measured, Attributes can be normalised for comparisons that will allow for more precise decisions around climate strategies.

A behaviour change occurs when a person is presented with an alternative option, so attributes can either encourage or discourage specific behaviours. If an alternative is perceived as safer, simpler, more affordable, etc, than the status quo, it becomes more appealing. An example of an encouraging attribute would be reducing the cost of public transportation to be less than purchasing fuel for a car trip of the same distance. On the other side, a discouraging attribute could be increasing the cost of public parking spaces, to make travelling by car more inconvenient.

As discussed, the TEF taxonomy allows for the expansion of layers into more detailed sub-layers. One way to extend the "Attributes" layer in future iterations is by standardising the way city attributes are defined and measured. For example, expressing attributes like the percentage of the population within 10 km of work who have access to safe cycling paths or the percentage of households using gas boilers older than five years in a standardised way enhances our ability to compare data across different cities. This, in turn, improves our assessments of how these attributes influence perceptions and behaviours, ultimately leading to more effective climate mitigation strategies.

Behavioural Changes

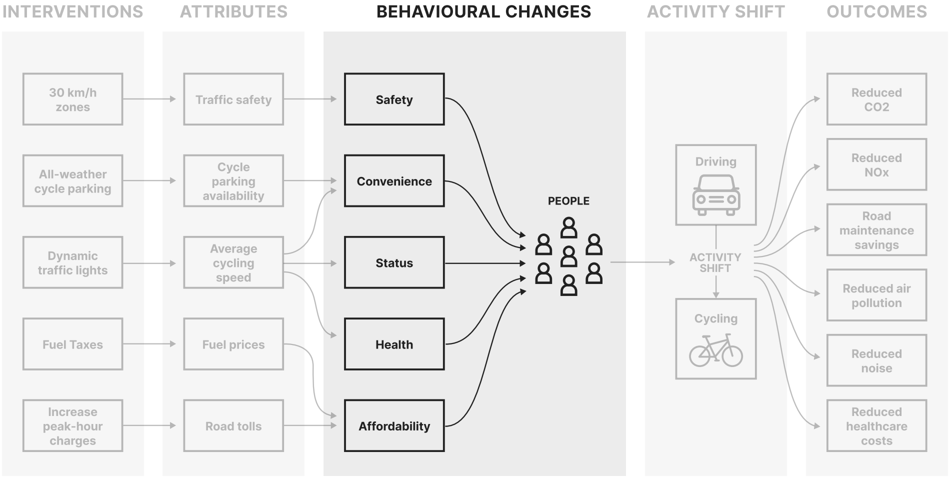


Figure 7. Behavioural changes are shifts in practices driven by public perceptions of attributes.

Behavioural changes are driven by perception, and perception refers to how the city's population views concrete attributes like fuel prices or traffic safety. For instance, if cycling infrastructure is perceived as safe and convenient, more people are likely to choose cycling over driving. Behaviour represents the actual practices adopted by the population, which ultimately lead to the Activity Shifts.

Perception varies across different demographics and includes aspects such as safety, convenience, status, health, and affordability. Understanding perception is essential for influencing behaviour, but predicting future decisions of individuals is nearly impossible. Still, we can look at the chain of reasoning behind observed behaviour changes in other cities and, together with this framework, clarify the reasoning behind the predictions. Perceptions will always vary, but showing them related to this chain of reasoning allows for the articulation of interventions and to start comparisons between cities–what has worked, and what hasn't. This chain of reasoning is in essence using logic to give a clear and logical argument for one activity to be chosen over another.

The list of perceptions presented by the taxonomy is based on multiple theories of behaviour change and useful patterns of human perceptions. It is intended to serve as examples rather than to be prescriptive and these examples cannot be considered MECE in practice as it is not possible for a list of this nature to be comprehensive or exhaustive.

Activity Shift

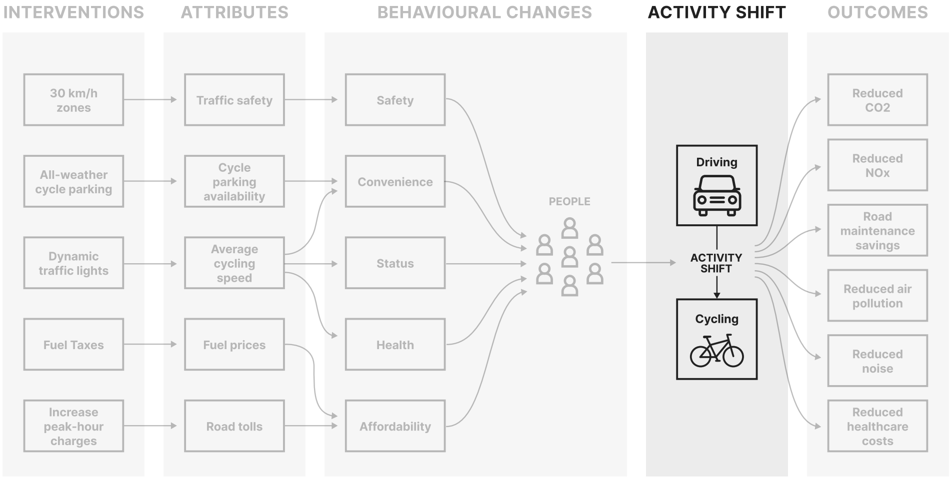


Figure 8. Activity Shifts are the transformation from high-carbon activities into lower ones. This is essential for achieving climate mitigation goals and the core of the Outcome Logic model.

A society is a hub of activities, carried out by individuals and organisations to fulfil a need of that society (nourishment, shelter, transportation, etc). The IPCC, in its emissions guidelines, describes how to calculate the emissions and resource usage of activities, and fundamentally, achieving a sustainable transition in a society means transforming, or shifting, the activities that meet these needs from high emitting to low or zero-emitting. Activities can be categorised across three types:

- **Extraction Activities (resources we attain):** Primary processes that concern the extraction, refining and processing of raw materials and energy generation activities such as wind, hydro, and fossil fuel-based electricity production. These activities are often significant sources of emissions and are detailed in the IPCC emission guidelines.

Table 4: Examples of Extraction Activities

Examples of Extraction Activities	**IPCC Reference**
Production of steel	IPCC 2019 Refinement Volume 3, Section 4.2
Production of hydrogen	IPCC 2019 Refinement Volume 3, Section 3.11

- **Production Activities (goods we produce):** Secondary processes involving producing goods, services and infrastructure and consuming raw materials and resources. This includes manufacturing, construction, and food production. The IPCC emission guidelines do not typically provide detailed emission calculations for these activities. The TEF includes these activities because they are often the focus of Mitigation Options and/or enabling technologies.

Table 5: Examples of Production Activities

Examples of Production Activities	**IPCC Reference**
Production of ICE vehicles	Indirectly via multiple extraction activities e.g. production of steel.
Manufacture of electronic equipment	IPCC 2019 Refinement Volume 3, Section 6.2

- **Behavioural Activities (things we do):** Tertiary activities refer to measurable things we do, such as kilometres driven by cars or square metres heated, that typically consume resources and thus cause emissions. These activities are detailed in the IPCC emission guidelines.

Table 6: Examples of Behavioural Activities

Examples of Behavioural Activities	IPCC Reference
Kilometres driven by cars	IPCC 2006 Guidelines Volume 2, Section 3.2
Square metres heated	IPCC 2006 Guidelines Volume 2, Section 2.3

The concept of “Activity Shift” is central to our interpretation and structuring of the IPCC’s Mitigation Options. It provides a systematic approach to transitioning activities from high-carbon to lower-carbon practices. This framework is designed to organise and define these shifts in a way that is both measurable and actionable, aligning with the IPCC’s emissions guidelines. By doing so, we create a comprehensive taxonomy and ontology that standardises the understanding of how activities can be transformed to achieve sustainability goals.

Activities can be broken down into two parts – their operations, which fulfil the need, and the work done, which refers to the chemical or physical transformations required to make it happen. Operations are measured in operational units that capture the value created by the activity. If a house is being heated, the operational unit is the area of the home that is heated (e.g. m^2). If it’s a car being driven, it’s the distance travelled by the car (vehicle km).

For the operations to fulfil the need, however, work must be performed. All activities require some kind of work – it represents the chemical or physical transformation of energy necessary to deliver the operations, like fuel combustion in an engine or photosynthesis within a plant, for example. To perform that work, the activity must consume resources – electricity, construction materials, or fuel for example. Some activities can produce resources, too, such as a combined heat-and-power plant.

Almost all activities also produce waste, and the TEF refers to these unintended byproducts of work as emissions. Emissions is a term that is normally used in connection with greenhouse gases or air or water pollution. But here it can also refer to other unintended byproducts, such as noise or heat. These quantifiable relationships are summarised in Figure 9.

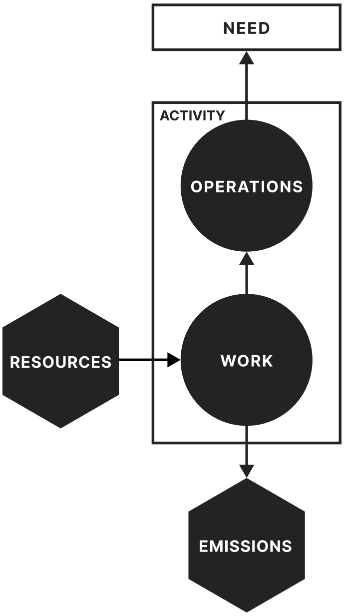


Figure 9. Activities are broken down into operations and work. The operations are measured in operational units, while the work consumes resources and creates emissions.

An Activity Shift can involve either shifting from one activity to another more sustainable one or transforming an existing activity to reduce its carbon impact. These shifts are quantifiable and represent opportunities to reduce resource use, emissions, or both. For example, a shift from driving fossil-fueled cars to cycling not only reduces emissions but also meets the same transportation needs in a more sustainable way. Similarly, transforming an existing activity, such as retrofitting buildings for energy efficiency, is another form of Activity Shift.

This framework models these transitions by encapsulating the need, the original and new or transformed activities, and the shift between them into a single unit: the Activity Shift. This unit captures the tangible, physical changes necessary for moving towards more sustainable practices. By setting specific targets for these shifts—such as a certain percentage increase in cycling or energy efficiency improvements—the framework helps define the scale of change and the corresponding outcomes we aim to achieve.

The term “Activity Shift” was carefully chosen to clearly define the objective within the framework. The shift itself, along with its specific targets, represents the desired objective of the Mitigation Option. This distinction is crucial because it separates the objective (the Activity Shift) from the means (the interventions and measures used to facilitate this shift). By focusing on the Activity Shift as the objective, the framework ensures that all efforts are directed towards achieving tangible, measurable changes in how activities are conducted or transformed, leading to the ultimate goal of reducing emissions and resource use.

“Activity Shifts” are anchored in the detailed and indexed classification of Activities as defined by the IPCC emissions guidelines. This alignment ensures that the terminology and structure used in this framework are consistent with the IPCC’s established methodologies, providing a robust foundation for analysing and implementing Mitigation Options.

It is important to note that because the TEF definition of a Mitigation Option focuses on Activity Shifts, technologies and infrastructures that support or enable these shifts, but do not directly represent a shift in activity themselves, are not classified as Mitigation Options. Examples include grid batteries, hydrogen storage facilities, and charging infrastructure. These are considered Enabling technologies.

Enabling technologies are crucial for the successful implementation of Mitigation Options, but they are not defined as Mitigation Options per se. For instance, energy storage technologies and flexible grids are essential for integrating a larger proportion of renewable energy, and charging infrastructure is vital for electrifying mobility and freight transportation. However, these are not Activity Shifts; they enable the Activity Shifts that are central to our mitigation framework. This distinction helps maintain a clear and focused definition of Mitigation Options, separating the direct actions that lead to Activity Shifts from the supportive technologies that make these actions feasible.

Categories of Activity Shifts

Activity Shifts can be of several categories, such as changing the type of activity (e.g., shifting from ICE vehicles to EVs), making an activity more efficient (e.g., retrofitting buildings), or utilising an activity more efficiently.

The six categories of Activity Shifts presented in Table 5 are an extension of the often-used “Avoid, Shift, Improve” categorisation of Mitigation Options. We argue that this new categorisation is a MECE (Mutually Exclusive, Collectively Exhaustive) list as all possible permutations of physical transformations and mechanisms of change will fall into at least one of the six categories presented here.

One Mitigation Option can contain one or any combination of these Activity Shifts. The transition to electric vehicles, for example, can be considered a Type Shift (exchanging one activity for another), a Resource Shift (replacing a resource with a more sustainable alternative), and arguably also a Work Efficiency Shift (performing less work to achieve the same outcome).

Table 7. Categories of Activity Shifts

Name	Mechanism of change
Type Shift	Transitioning from a high-carbon Activity to a lower-carbon alternative.
Resource Shift	Replacing existing resources with more sustainable alternatives, usually substituting high-carbon inputs with low-carbon or renewable resources. This often means we can keep the same machine and replace the fuel type, like filling a diesel car with biodiesel.
Utilisation Shift	Focusing on minimising the overall need for an Activity by cutting down the frequency or intensity of the activity itself, either by improving its efficiency (to reduce how often it's needed) or reducing the overall demand for that activity.
Work Efficiency Shift	Improving the conversion of Work to Operations by targeting the efficiency with which the produced work is used to carry out operations or achieve the desired output or performance in a process. The goal is to perform less work to achieve the same amount of operations.
Resource Efficiency Shift	Improving the conversion of Resource to Work by shifting towards more efficient use of a resource. The goal is to use less of the resource to perform the same amount of work.
Carbon Shift	Enhancing or adding complementary Activities that increase the capacity for carbon sequestration. Carbon, in the form of CO_2, is captured from the air and consumed as a resource. It can be converted to biomass via photosynthesis or stable carbonates via mineralisation, among other transformations.

Type Shift

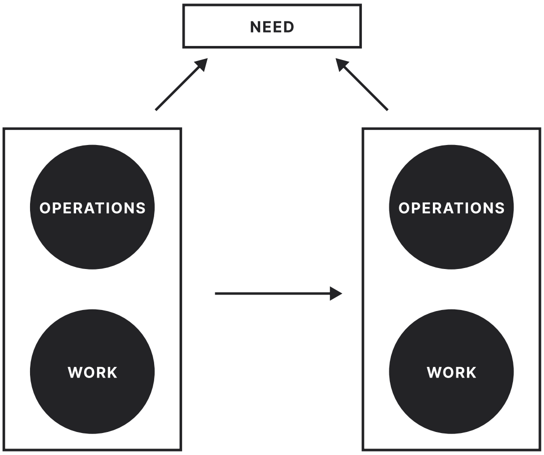


Figure 10. Type Shift: Shifting from one type of Activity to another.

Mechanism of change: Transitioning from a high-carbon type of activity to a lower-carbon alternative.

Examples of Mitigation Options:

- Shifting from ICE vehicles to EVs.
- Shifting from ICE vehicles to cycling and walking.
- Shifting from diesel-fuelled freight trucks to electric freight trucks.
- Shifting from gas boilers to heat pumps.

Resource Shift

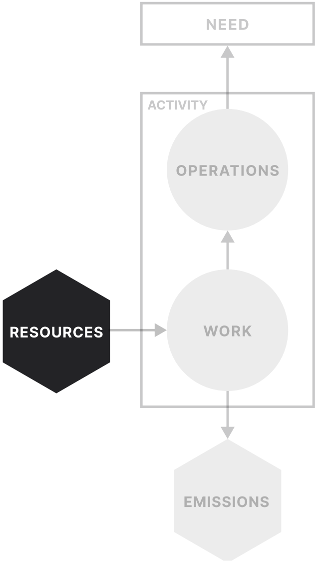


Figure 11. Resource Shift: Shifting from one resource to another.

Mechanism of change: This shift includes replacing existing resources with more sustainable alternatives, usually substituting high-carbon inputs with low-carbon or renewable resources. This often means we can keep the same machine and replace the fuel type, like filling a diesel car with biodiesel.

Examples of Mitigation Options:

- Using biofuel instead of diesel.
- Switching to renewable energy sources like wind or solar.
- Shifting feedstock for cattle to lower methane emissions.

Utilisation Shift

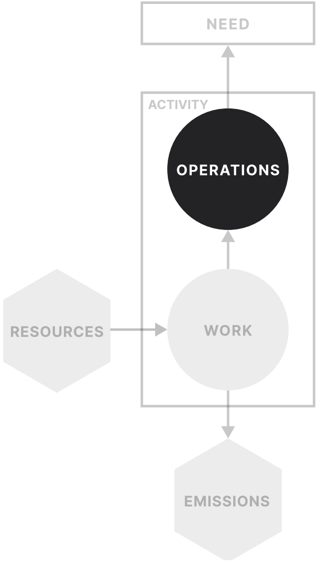


Figure 12. Utilisation Shift: Reducing the operations of an Activity.

Mechanism of change: Focusing on minimising the overall need for an Activity by cutting down the frequency or intensity of the activity itself, either by improving its efficiency (to reduce how often it's needed) or reducing the overall demand for that activity.

Examples of Mitigation Options:

- Implementing car-sharing programs, thus reducing the number of operations required.
- Route optimisation for delivery vehicles.
- Increasing use of second-hand clothes.
- Reducing food waste.
- Urban Area planning, thus reducing the need for transport.

Work Efficiency Shift

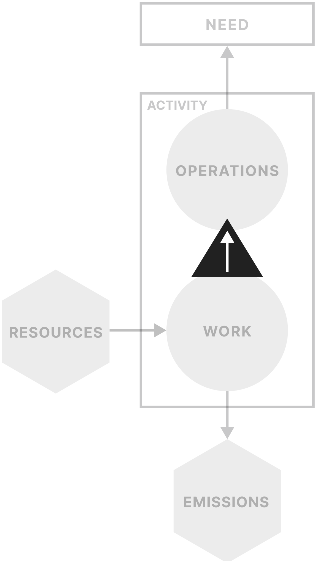


Figure 13. Work Efficiency Shift: Improving the Work to Operations Efficiency.

Mechanism of change: Improving the conversion of Work to Operations by targeting the efficiency with which the produced work is used to carry out operations or achieve the desired output or performance in a process.

The goal is to perform less work to achieve the same amount of operations.

Examples of Mitigation Options:

- Optimising industrial processes to use less energy.
- Retrofitting buildings with improved insulation and smart controls for energy efficiency.

Resource Efficiency Shift

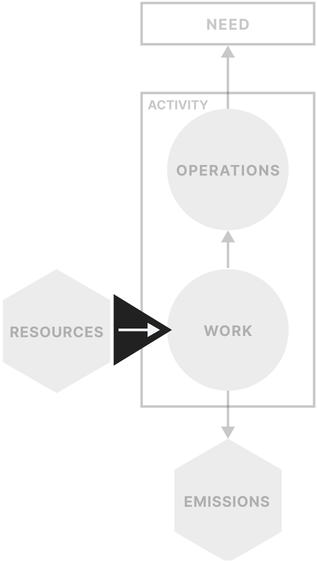


Figure 14. Resource Efficiency Shift: Improving the Resource to Work Efficiency.

Mechanism of change: Improving the conversion of Resource to Work by shifting towards more efficient use of a resource. The goal is to use less of the resource to perform the same amount of work.

Examples of Mitigation Options:

- Developing more efficient internal combustion engines to improve fuel efficiency.
- Improving heat pump efficiency to produce the same amount of heat with less electricity (COP value of heat pump).
- Upgrading furnaces in CHP systems improves efficiency by optimising fuel consumption and heat utilisation.

Carbon Shift

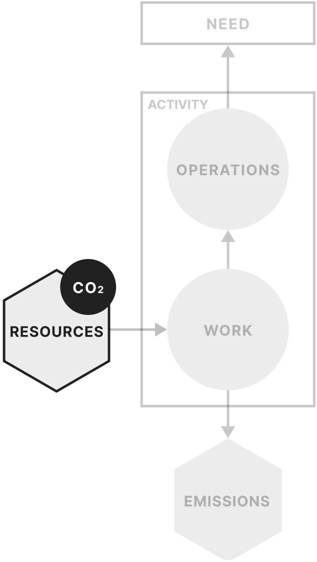


Figure 15. Carbon Shift: Adding or improving Activities that sequester or utilise CO_2.

Mechanism of change: Enhancing or adding complementary Activities that increase the capacity for carbon sequestration. Carbon, in the form of CO_2, is captured from the air and consumed as a resource. It can be converted to biomass via photosynthesis or stable carbonates via mineralisation, among other transformations.

Examples of Mitigation Options:

- Reforestation projects.
- Soil carbon sequestration.
- Enhancing urban green spaces.
- Carbon capture and storage (CCS).
- Carbon utilisation in industry and manufacturing.

Activity Shifts and the Circular Economy

In 1972, The Club of Rome published The Limits to Growth, where the authors used computer models to indicate that our planetary resources could not support infinite economic growth[5]. Based on these models, the authors suggested that if growth of our global economy was left unchecked, we would be heading towards sudden and uncontrollable population and industrial capacity declines within a century. The societal debate that resulted from The Limits to Growth contributed to the emergence of the circular economy concept as a potential solution to these resource and environmental challenges.

The circular economy's core principle revolves around optimising the use of resources and activities, primarily through reducing waste, extending product life cycles, and innovating in material reuse and recycling. This mirrors the fundamental aim of climate mitigation, which focuses on shifting activities to reduce emissions. Therefore, circular economy initiatives are not merely environmental strategies; they are, in essence, climate actions framed within the context of creating more sustainable and resilient systems. The TEF, with its focus on structured, systematic shifts in activities, seamlessly supports these circular economy transitions, making it an adaptable tool for describing both climate mitigation and resource efficiency goals.

Industrial clusters[6] represent a prime example of the circular economy in action. In these clusters, businesses are located near one another, allowing them to share resources and infrastructure and optimise energy and material flows. Key to the circular economy, by-products or waste from one manufacturing process become resources for another. Industrial clusters can also reduce the travel distance and infrastructure required for commodities by co-locating producers and consumers.

5. Meadows, D.H., Meadows, D.L., Randers, J., & Behrens III, W.W. (1972). *The Limits to Growth*. Universe Books.

6. For a reference, see Kalundborg Symbiosis in Denmark. Kalundborg is one of the pioneering and most successful industrial clusters, with 17 public and private companies sharing and reusing resources.

Outcomes

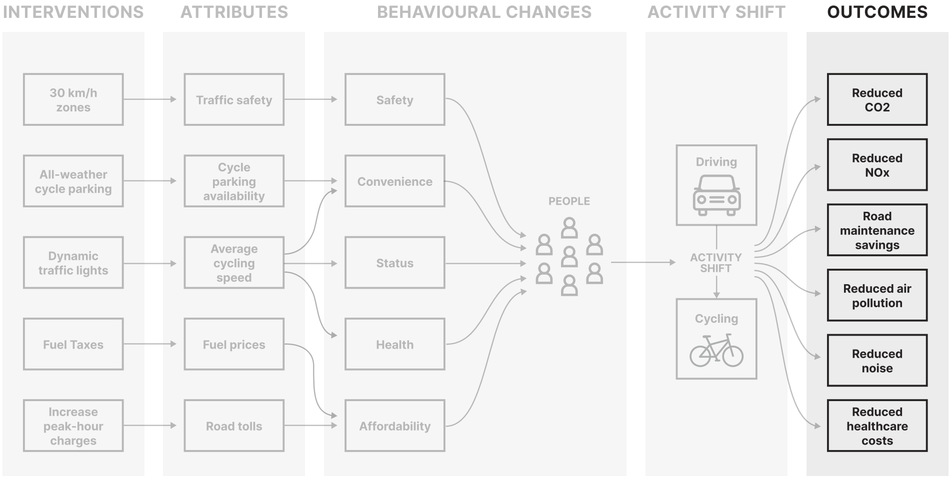


Figure 16. Outcomes are the measurable results of Activity Shifts, reflecting the specific environmental, social, and economic benefits achieved.

With the Outcome Logic laid out, step by step, it's clear to see that its nucleus is the Activity Shift, the shift from one activity to another. These shifts are what deliver desired outcomes, and they're what interventions from officials strive to achieve.

Once the Activity Shifts are defined, the next step is to understand their Outcomes. Outcomes are the measurable results of implementing the Activity Shifts and are directly related to the scale of the Activity Shifts. These include reductions in greenhouse gas emissions, but also other environmental, societal and economic benefits such as improvements in air quality, reduced road maintenance costs, reduced health costs, jobs created (and increased tax income because of this), etc. We can call these co-benefits. By quantifying these outcomes, municipalities, regions and nations can assess the effectiveness of the Mitigation Options and understand the specific impact of achieving certain targets for Activity Shifts.

To illustrate the reduction of greenhouse gas emissions due to an Activity Shift, please refer to the fictive example in Figure 6. The GHG reduction depends on the target value set by the decision-makers of a municipality, region or nation.

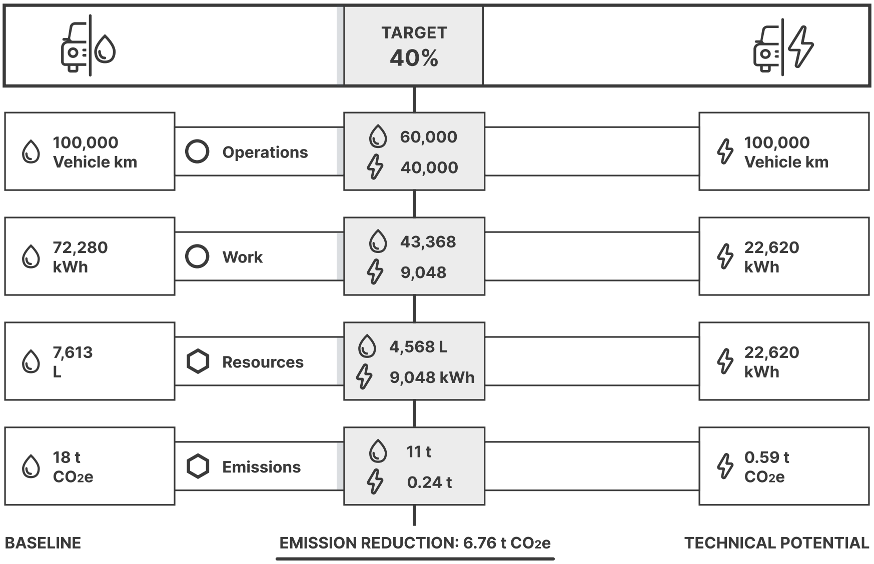


Figure 17. Illustration of greenhouse gas reduction calculation for the Activity Shift "Increased proportion of EVs".

To calculate the co-benefits an economic model would have to be applied that connects with the activity-based data model. For an introduction to this method of economic modelling, see the White paper: Data-Driven Transitions.[7] The TEF taxonomy is planned to be expanded upon to incorporate this costs and values assessment in the framework.

[7] Shalit, T., Dixon, M., & Eklöw, K. (2024). *Data-Driven Transitions Revised Edition*. ClimateView. Available for download: https://www.climateview.global/

CLARITY AND COVERAGE THROUGH MECE

The measurability of the TEF layers that was previously introduced is made possible by the framework's adoption of the MECE principle. The TEF layered approach is a MECE description of a Mitigation Option, meaning each layer addresses a distinct aspect without overlap, and together, they cover all components. By adhering to the MECE principle, this model ensures both comprehensiveness and clarity, avoiding redundancy and supporting the assessment of all critical factors considered in the transition towards sustainable cities, regions, and nations.

Here’s how MECE is applied within this layered approach:

- **Distinct and Non-Overlapping Layers** (Mutually Exclusive): Each layer in the TEF is designed to address a specific aspect of the mitigation process without overlapping with other layers. For instance, the “Attributes” layer describes measurable, objective characteristics of the city, like traffic safety, public transportation availability, or the extent of green spaces. Meanwhile, the “Perceptions” layer addresses how these attributes are viewed by the population, influencing their behaviour.
- **Comprehensive Coverage Across Layers** (Collectively Exhaustive): Together, these layers provide a complete view of the mitigation process. They cover everything from decision-making and environmental changes to behavioural adjustments and their ultimate outcomes. This ensures that all necessary elements are included, giving us a holistic view of the transition to lower-carbon activities.

The interfaces between layers are key to the TEF’s effectiveness. An interface is where two layers interact and influence each other.

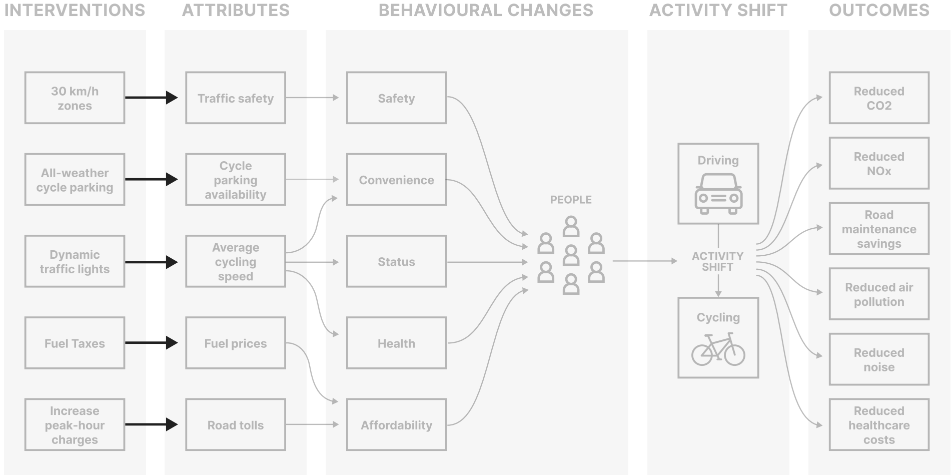


Figure 18. Interventions shape attributes by translating policies, investments, and actions into tangible physical and economic changes.

For instance, there's a clear interface between the "Interventions" layer and the "Attributes" layer. Interventions (such as policy changes, infrastructure investments, or financial incentives) represent the decisions or strategies that guide what should happen. These interventions exist "in the abstract" until they are implemented. When these plans are put into action, they result in real-world changes in the "Attributes" layer.

The "Attributes" layer includes both physical and economic aspects of the environment, such as the creation of bike lanes, the installation of solar panels, the cost of parking, or the price of heat pumps. This marks the transition from planning to tangible outcomes, where the strategies are realised and their effects can be measured and observed.

Similarly, there's an interface between "Attributes" and "Perceptions," where real-world changes (attributes) influence how people perceive their environment.

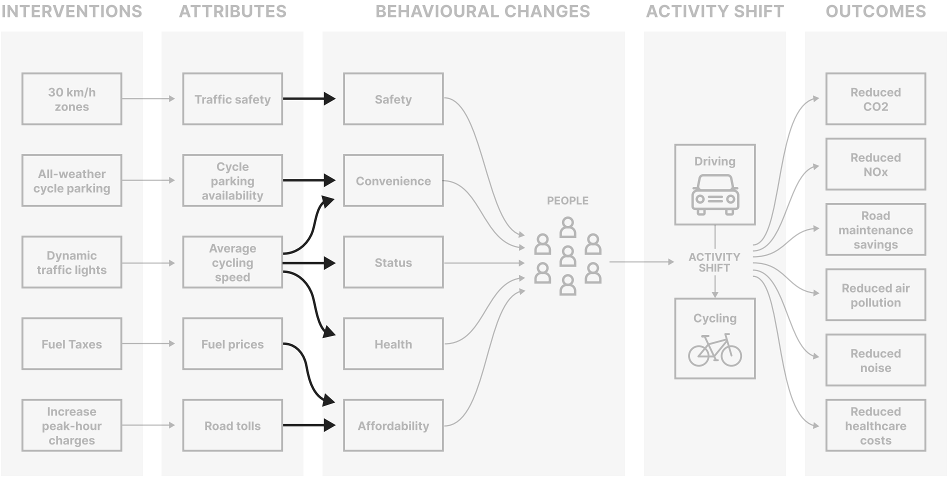


Figure 19. Attributes influence behavioural changes as public perceptions of safety, convenience, and affordability drive shifts in daily practices.

While each layer in the TEF is distinct and non-overlapping, it can be further organised into more detailed sub-layers or other structures. For example, within the "Attributes" layer, we can create categorisations based on different types of attributes, such as infrastructure, environmental quality, or social amenities. Alternatively, we could develop a hierarchy of attributes, where broad categories are divided into more specific components, or connect attributes to spatial maps for geographic visualisation.

This flexibility in organisation is possible as long as the boundaries—or interfaces—between layers are maintained. These interfaces ensure that each layer continues to interact with adjacent layers in a clear and consistent manner, preserving the integrity and coherence of the framework. It also allows the framework to adapt to various contexts and scenarios. For example, an object might function as an enabling technology in one Transition Element and as an attribute or direct Mitigation Option in another.

Enabling a multi-faceted view

The framework allows for a multi-faceted view on the same objects, enabling a more nuanced understanding of their roles in the transition to sustainability. While batteries, for instance, are generally considered enabling technologies, they can also be viewed as part of a Mitigation Options under certain conditions. For example, if we focus on the activity of "battery production," a Mitigation Option might involve making this production process more efficient through a resource or utilisation shift.

Similarly, enhancing urban green spaces can serve as a Mitigation Option under the category of carbon sink enhancement. However, these green spaces can also be viewed as attributes that promote other Mitigation Options, such as increasing cycling by providing more pleasant and safe environments for cyclists.

These examples illustrate how the same object can function as a technology enabler, an attribute, and a Mitigation Option. This multi-faceted view means that the same technology or strategy can be analysed from different angles: as an enabling technology in one context, an attribute in another, and a direct Mitigation Option in yet another. This flexibility allows us to capture the complex interconnectivity of various elements within the framework, providing a comprehensive view of how different strategies contribute to the overall goal of reducing greenhouse gas emissions and improving sustainability.

By incorporating this multifaceted view, our framework can address multiple dimensions of the transition, offering a richer and more detailed understanding of how various components interact and support each other in achieving effective mitigation outcomes.

CONCLUSION

The TEF originated from a multi-year collaboration between ClimateView, the Swedish Climate Policy Council, the Swedish Energy Agency, and the Swedish Environmental Protection Agency. It was co-developed with cities across the globe, including the Ruhr region in Germany, and most recently, with the Scottish Climate Intelligence Service (SCIS). Components of the TEF are also being used in pursuit of a German Institute for Standardization (DIN) specification and subsequently a European Committee for Standardization (CEN) standard. The framework is part of a larger open-source project comprising four interconnected resources that create a comprehensive pathway from IPCC knowledge to referenced data for operationalising climate action plans.

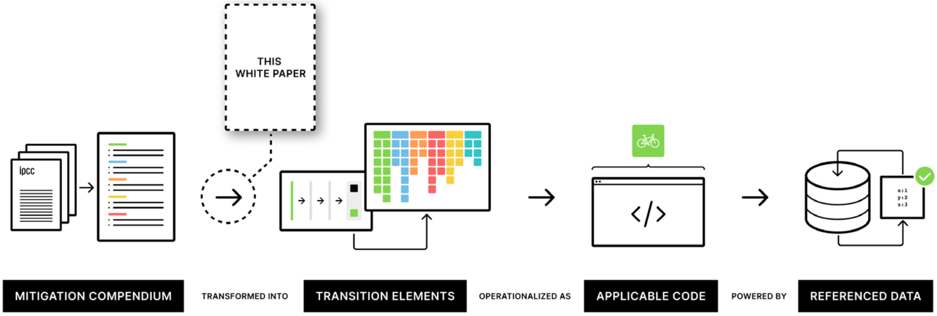


Figure 20. This white paper is part of an open-source project with four resources designed to facilitate the implementation of IPCC Mitigation Options.

- **Mitigation Compendium:** A curated collection of the IPCC's Mitigation Options outlined by Working Group III in their contributions to AR4, AR5, and AR6.
- **Transition Elements:** Structuring Mitigation Options into actionable building blocks for practical climate action.

- **Applicable Code:** A structured, machine-readable way to describe each Transition Element using YAML models.
- **Referenced Data:** Provides reliable, vetted data for implementing the Transition Elements that are tailored to the needs of each Mitigation Option.

With the TEF, we have created a structured, clear, and comprehensive framework for analysing and implementing climate mitigation strategies. Each layer is distinct and non-overlapping, ensuring that all aspects of the mitigation process are addressed without redundancy. The framework's flexibility allows for detailed exploration within each layer, while the well-defined interfaces between layers ensure that the overall system remains coherent and effective. This approach makes the TEF both robust and adaptable, capable of guiding complex climate mitigation efforts across various contexts.

Looking Forward: Building on the TEF Framework

This paper intentionally avoids detailed methodologies of systemic scenario modelling. Instead, it emphasises how this framework supports various modelling approaches, which will be explored in future publications. The primary focus here is to lay the groundwork for establishing a clear taxonomy and ontology for Mitigation Options through the Transition Elements (TEs), which form the foundation for understanding and organising climate mitigation strategies.

The TEF's modular design, with its clearly defined layers and interfaces within and between each transition element, supports the modelling of complex system behaviour. This design is structured considering the phenomenon of emergence, where the whole system's behaviour is far more intricate than the sum of its parts and the rules governing them. With emergence, properties can not be directly predicted from the parts of a system alone, as simple interactions between individual components give rise to complex, system-wide behaviours. In ClimateView, we utilise agent-based modelling to simulate these interactions, where each transition element acts as an “agent” within a larger system. These agents interact with each other, leading to emergent behaviours that reflect the complexities of real-world systems. This allows us to model how systemic dynamics unfold, revealing how changes in one area, such as energy production, impact the effectiveness of transitions in other areas, such as the adoption of electric vehicles.

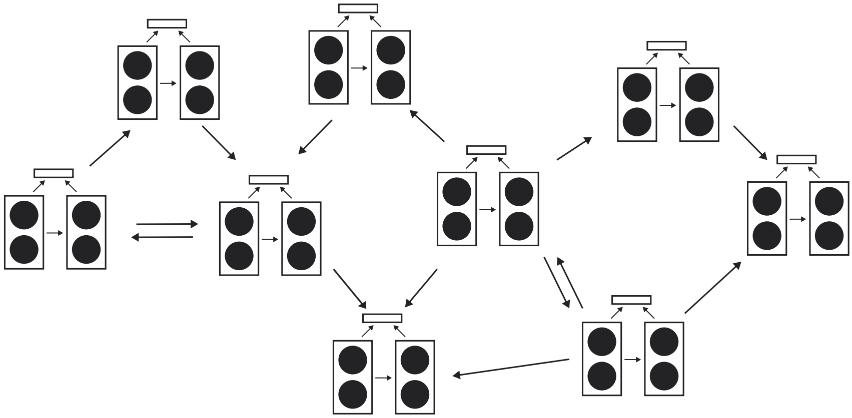


Figure 21. The TEF's modular design, with its Transition Elements, facilitates the modelling of complex system behaviour through defined layers and interfaces, supporting simulations that reveal emergent dynamics within climate mitigation strategies.

The TEF in practice

The TEF's modular approach, combined with agent-based modelling, allow for scalability. Whether you're working with a few transition elements or many, this flexibility means that models can be as simple or complex as needed, ranging from small-scale simulations to comprehensive national systems. This section will explore how the TEF framework is currently applied in practice through the ClimateView platform, showcasing real-world examples.

As previously stated, new technology platforms that work interoperably with IPCC knowledge have the potential to propel us into a new era of enhanced climate action. The TEF is utilised by ClimateView where all of the underpinning data is made available to users of the platform. Through the platform, the TEF is used to help a city assess current and future climate interventions to meet its goals. Early collaborations between ClimateView and key Swedish agencies evolved into Panorama, a roadmap to climate neutrality for Sweden[8]. Panorama highlights how the data and insights from the platform can be published to increase the transparency of climate action plans.

[8] https://panorama-sweden.com/

Net zero 2045

Sweden's greenhouse gas emissions were 45.2 million tonnes in 2022, which means a reduction of 5 percent compared to 2021. Since 2010, they have decreased by 30 percent, since 1990 by 37 percent. The overall target is to reach net zero emissions by 2045. By then, emissions must be at least 85 percent lower than in 1990. Remaining emissions may be credited through supplementary measures.

Transition for Sweden

460 kt
reported emissions 2020
recorded amount of CO2 emissions released into the atmosphere

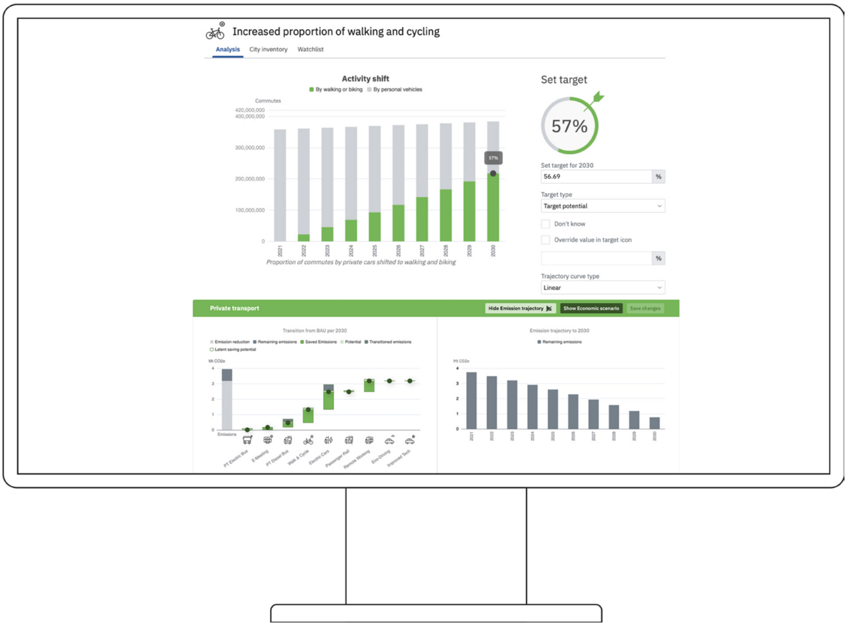
+14%
projected emissions 2045
percentage change in CO2e if we do nothing

-100%
projected emissions 2045
percentage change in CO2e if we reach our goal

Net zero 2045

Sweden's greenhouse gas emissions were 45.2 million tonnes in 2022, which

Figure 22. Panorama is an open-access platform for visualising Sweden's climate transition, built upon official data and public information.



Set target for 2030: 56.69 %

Target type: Target potential

☐ Don't know

☐ Override value in target icon

Trajectory curve type: Linear

Figure 23. Activity Shifts and targets seen in ClimateView.

Examples of ClimateView and the TEF in practice include:

- **Panorama:** An open-access platform for visualising Sweden's climate transition that builds upon official data and public information. Panorama was developed in collaboration with the Swedish Climate Policy Council, the Swedish Energy Agency and the Swedish Environmental Protection Agency. This data structure is updated regularly as policy evolves and emissions data changes.
- **Scotland:** Scotland's 32 local authorities use ClimateView to coordinate a nation-wide climate transition. Through the collaborative platform, the various authorities are enabling systemic changes by addressing specific climate targets while still incorporating the interconnected nature of carbon emissions. This initiative is being led by the Scottish Climate Intelligence Service (SCIS) with support by the Government of Scotland.
- **Ruhr Region:** A former hub of German coal and steel, the Ruhr Region now aims to be the world's greenest industrial region by 2045. The Ruhr Regional Association is leveraging the ClimateView platform to integrate its climate efforts, promoting transparency, economic resilience, and citizen-centric planning across its 53 municipalities and five million inhabitants.

The TEF is applied within the ClimateView platform and on data from over 150 cities. These three examples highlight the TEF's modularity, which allows it to adapt to context-specific situations and the flexibility to work both within and across sectors. The TEF is used to model Mitigation Options systemically, and with this comes the ability for advanced scenario planning and simulation.

Future applications

Recognising the value of this standardisation, we plan to continuously expand this open-source framework by developing a library of standardised city attributes. As we gather more data and experience from cities worldwide, this library will grow, becoming increasingly detailed and comprehensive. This ongoing expansion will enhance the framework's ability to guide climate action across diverse contexts and serves as an example of how this initiative—a shared taxonomy within the TEF—can accelerate knowledge-sharing and experiences between cities. By adopting a common language for describing and analysing mitigation strategies, cities can more easily collaborate, learn from each other, and implement successful interventions more rapidly.

Additionally, accelerated insights and new perspectives for data-informed decisions can be delivered through the application of artificial intelligence to this growing library. The TEF ontology and taxonomy offer the ideal structure and knowledge base for AI-powered decision-making around climate Mitigation Options. It allows for the engineering of a lens that prompts AI to understand and suggest climate policies as well as to look for clear real-world examples. Having a clearly mapped formal ontology is a powerful tool for AI applications, and future white papers will go into greater depth on how ClimateView is using this technology in practice[9,10].

The modular and structured nature of the TEF allows for continuous refinement and enhancement of the models built upon it. As more data becomes available and our understanding of the interactions deepens, these models can evolve to capture more complex dynamics and provide increasingly accurate predictions. This ongoing evolution is crucial because it allows the modelling processes to adapt and grow in sophistication, ensuring they remain effective in addressing emerging challenges in climate mitigation.

9. Gruber, T. R. (1993). A translation approach to portable ontology specifications. *Knowledge acquisition*, 5(2), 199-220.

10. Confalonieri, R., & Guizzardi, G. (2023). On the Multiple Roles of Ontologies in Explainable AI. *arXiv preprint arXiv:2311.04778.*

One potential future evolution enabled by the TEF framework is the modelling of portfolios of interventions. In this scenario, the models could be developed to understand how multiple interventions interact within a system, either supporting or counteracting each other. For example, the framework could help model how a combination of policies promoting renewable energy, energy efficiency, and transportation electrification might collectively influence several transitions simultaneously. By simulating these interactions, the models could reveal synergistic effects where interventions amplify each other's impact, as well as potential conflicts where one intervention might inhibit the progress of another. This type of advanced modelling, supported by the TEF's taxonomy and ontology, would provide deeper insights into how to strategically plan and implement climate actions to maximise their overall effectiveness.

Glossary

Activity A physical or biological process that a person performs to fulfil a need. Food being consumed or a house being heated are activities. An activity always consumes resources and produces emissions. Some activities produce resources too, such as a combined heat-and-power plant. An activity consists of work and operations.

Activity Shift The change from a high-carbon activity to a low-carbon activity that both fulfil the same need, e.g. changing from driving a car to riding a bike or walking. The Activity Shift is the nucleus of any Transition Element. There are more than 100 Activity Shifts each falling into one of six categories: Type Shift, Resource Shift, Utilisation Shift, Work Efficiency Shift, Resource Efficiency Shift, Carbon Shift. Each Activity Shift can have an individual target and tempo, and are interconnected through the resources going into the underlying activities.

Attributes The tangible, observable outcomes of interventions. Attributes are measurable properties of the local environment with characteristics that reflect the implementation of interventions.

Behaviour (change) A behaviour is a choice of activity to meet a certain need; a behaviour change is making a different choice to meet the same need. For example, a choice to commute by bicycle or bus instead of by car, or to buy second hand clothing over fast fashion. Behaviour change also encompasses longer-term decisions, like citizens retrofitting their home, as well as organisations and administrators making changes to their policies or processes.

(City) attribute(s) A property of the urban environment that encourages or discourages specific behaviours among the population. City attributes are measurable, e.g. the average distance to a bus stop, or the cost of buying a ticket, and are expressed in a normalised way allowing for comparisons between different urban areas.

Co-benefits Positive outcomes of an Activity Shift, other than CO_2-emission reductions, e.g. noise reduction, improved air quality, or health benefits through active mobility.

Costs All activities come with capital, resource, and emission costs which are measurable and are included in the economic model of each Transition Element. This means officials can make informed decisions about investments, maintenance, and lifecycle management of the assets that play a pivotal role in the transition.

Decision(s) Formal decision(s) taken by local authorities and city officials about the interventions to be implemented in order to reach the set objective(s).

Emissions Emissions are produced by the work performed as part of an activity. Usually this term refers to green-house gases or air or water pollution. But here it can also refer to other unintended byproducts, such as noise or heat.

Intervention(s) The set of actions, policies and projects connected to formal decisions taken in order to close the gap and to reach set objectives, e.g. introducing more 30 km/h zones or subsidising retrofitting of residential buildings.

MECE Mutually Exclusive, Collectively Exhaustive (MECE) is a principle used to organise information in a clear, structured, and comprehensive manner. MECE ensures that knowledge is grouped in a way that avoids overlap (Mutually Exclusive) and covers all possible actions without leaving any gaps (Collectively Exhaustive).

Mitigation Option An action, strategy, or set of measures outlined by the IPCC to reduce greenhouse gas emissions and address climate change. Each Mitigation Option targets a particular activity or sector—such as energy, transportation, or agriculture—and involves shifting from high-emission practices to more sustainable alternatives.

Need The reason why people execute activities. Needs include eating, keeping clean, working, travelling, communicating, socialising, recreation, etc.

Objective(s) Political goals, mandates, and aims that an administration has in its transition. This will almost certainly include local and national climate goals, but it may also include health, social, economic, and other goals. They define the overarching goal(s) for any scenario.

Ontology A structured framework that defines the relationships and interconnections between different elements within a system.

Operation(s) The part of an activity that fulfils the need and is measured in operational units that capture the value created. If a house is being heated, the operational unit is the area of the house that is heated. If it's a car being driven, it's the distance travelled by the car. Operations can be tracked and recorded as data.

Outcome(s) The result(s) of an Activity Shift, as a consequence of people changing their behaviour. This might include cleaner air, reduced CO_2 emissions, or improved health.

Outcome Logic The chain of reasoning tracing from interventions, to (city) attributes, to perceptions, to behaviour, to Activity Shifts, and ultimately outcomes.

Perception(s) Public perceptions of city attributes that drive peoples' behaviour. Perceptions fall into one of the following categories: safety, convenience, status, health, and affordability. They can differ between socio-economic groups, and are the core drivers of Activity Shifts.

Resource(s) In order to perform work, activities consume resources – electricity, construction materials, or fuel for example. Some activities can produce resources too, such as a combined heat-and-power plant.

Periodic Table of Transition Elements The collection of all Transition Elements sorted by sector (transport, industry, agriculture, energy, other), adding up to more than 100 in total. Each Transition Element represents an IPCC Mitigation Option.

Scenario A set of chosen Activity Shifts including their targets and tempos that can be updated and iterated over time. A scenario usually reflects the local circumstances and political priorities.

Taxonomy A systematic way of organising and categorising information into groups and subgroups based on shared characteristics.

Transition Element (TE) A comprehensive data model of the Outcome Logic each with one Activity Shift at its core, based on quantifiable physics.

Work The part of an activity that describes the chemical or physical transformation of energy required to deliver the operation, e.g. fuel combustion in an engine. Work consumes resources and produces emissions. Work can be tracked and recorded as data.

Figures

12. Utilisation Shift: Reducing the operations of an Activity.

13. Work Efficiency Shift: Improving the Work to Operations Efficiency.

14. Resource Efficiency Shift: Improving the Resource to Work Efficiency.

15. Carbon Shift: Adding or improving Activities that sequester or utilise CO_2.

16. Outcomes are the measurable results of Activity Shifts, reflecting the specific environmental, social, and economic benefits achieved.

17. Illustration of greenhouse gas reduction calculation for the Activity Shift "Increased proportion of commuting by electric bus".

18. Interventions shape attributes by translating policies, investments, and actions into tangible physical and economic changes.

19. Attributes influence behavioural changes as public perceptions of safety, convenience, and affordability drive shifts in daily practices.

20. This white paper is part of an open-source project with four resources designed to facilitate the implementation of IPCC Mitigation Options.

21. The TEF's modular design, with its Transition Elements, facilitates the modelling of complex system behaviour through defined layers and interfaces, supporting simulations that reveal emergent dynamics within climate mitigation strategies.

22. Panorama is an open-access platform for visualising Sweden's climate transition, built upon official data and public information.

23. Activity Shifts and targets seen in ClimateView.

Tables

About ClimateView

ClimateView is a Swedish technology company dedicated to the public sector's climate transition. Since 2018, ClimateView has collaborated with local, regional, and national organisations, including the Swedish Climate Policy Council and the Scottish Climate Intelligence Service. Working alongside officials, experts, and elected leaders from over 130 municipal authorities—including several EU Mission Cities—ClimateView has developed a comprehensive methodology, framework, and platform to drive climate change mitigation. By integrating expert knowledge with innovative technology, ClimateView provides the tools needed for cities and regions to effectively manage their transition towards a sustainable future.

Thank you!

We would like to thank all of you – experts, officers, and elected leaders from administrations, local, regional and national – involved in creating this methodology. It will continue to develop in collaboration with our partners, based on physics, technology, and scenario-building. Get in touch with us if you'd like to take part:

climateview.global/contact