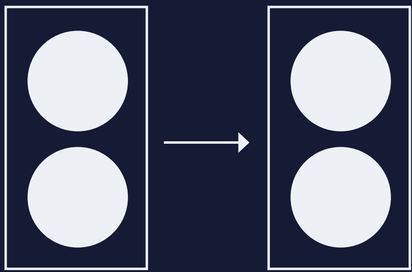

DATA-DRIVEN TRANSITIONS

A co-created methodology

Revised Edition

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About

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.

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INTRODUCTION

Public administration is a complex task, and new complexities unfold with every passing year. The shaping of societies in a warming world, with economies fit for the 21st century, requires new kinds of processes and institutions. These include climate action plans and investment strategies, climate budgets, green financing, and future energy frameworks. It also includes regional institutions like the EU Mission for 100 Climate-Neutral and Smart Cities, as well as global reporting processes like Nationally Determined Contributions (NDCs), and the Sustainable Development Goals (SDGs).

This white paper presents a scenario methodology to make it easier to work with these processes, including a supporting framework and platform. The approach is iterative, outcome-focused, and works alongside an administration's existing initiatives. It has been developed in partnership with local, regional, and national authorities across Europe.

Many of the ideas influencing decisions – like Doughnut Economics[1] , Planetary Boundaries[2] or Circular Economies[3] – come down to resources. These resources must be carefully managed to deliver a just transition, agreed between stakeholders as diverse as society itself. Different scenarios must be explored to understand how shifts in resource use, energy, and finance will impact the ability of citizens to fulfil their needs.

The core of the methodology is based on outcomes. It shows that reaching a particular outcome requires identifying specific activities for change, influenced by city attributes, and altered by interventions resulting from formal decisions. However, relying on perfect data to make those decisions slows progress. As a result, administrations are developing methods where data that is "good enough" can still be used. Even imperfect data can provide a sufficient foundation for good decision-making, when combined with models, mathematics, and – crucially – an iterative mindset.

This co-created methodology combines the precision of physics with the nuances of behavioural and economic science. It gives officials tools to identify, assess, and advocate for different scenarios. These scenarios are then refined repeatedly, helping administrations achieve their objectives with urgency, agility, efficacy, and full accountability.

PART ONE

THE METHOD

Administrations that wish to deliver a sustainable transition face a difficult task. Decision-makers must simultaneously create a compelling, ambitious vision for the future, while keeping that vision realistic and achievable. Doing both of these things together can be challenging.

The answer is to take an iterative approach, where a desired future scenario is roughly sketched out and refined over time, and the route to get there is regularly reassessed in light of changing circumstances, data gathered, and progress made. This strategy recognises that administrations need to be adaptable and responsive to new information, emerging technologies, and changing political and planetary conditions.

At its core, this approach separates "interventions" (i.e. formal decisions) from "Activity Shifts". The term "Activity Shift" is defined as a shift from one activity to another to fulfil a need. This allows planners to create scenarios for each Activity Shift, and test out different interventions to assess if the Activity Shifts can hit their targets, adjusting the approach over time so that the administration achieves its objectives.

It's also important to note upfront that this definition means it's often not possible for policymakers to influence an Activity Shift 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 urban environment.

Outcome logic

The methodology presented in this white paper is built on an outcome logic that shows that reaching a particular outcome requires planners to identify Activity Shifts they want to affect. These shifts are influenced by behavioural dynamics, which are influenced by measurable properties of the urban environment, known as city 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 to cycling.

Here, an intervention (1) is the result of a formal decision that leads to a change in city attributes (2). The perceptions that a city's population has of these attributes will encourage or discourage different behaviours (3), and a shift from one activity to another over time (defined above as an "Activity Shift" (4) will lead to one or more outcomes (5) in terms of carbon abatement and other benefits.

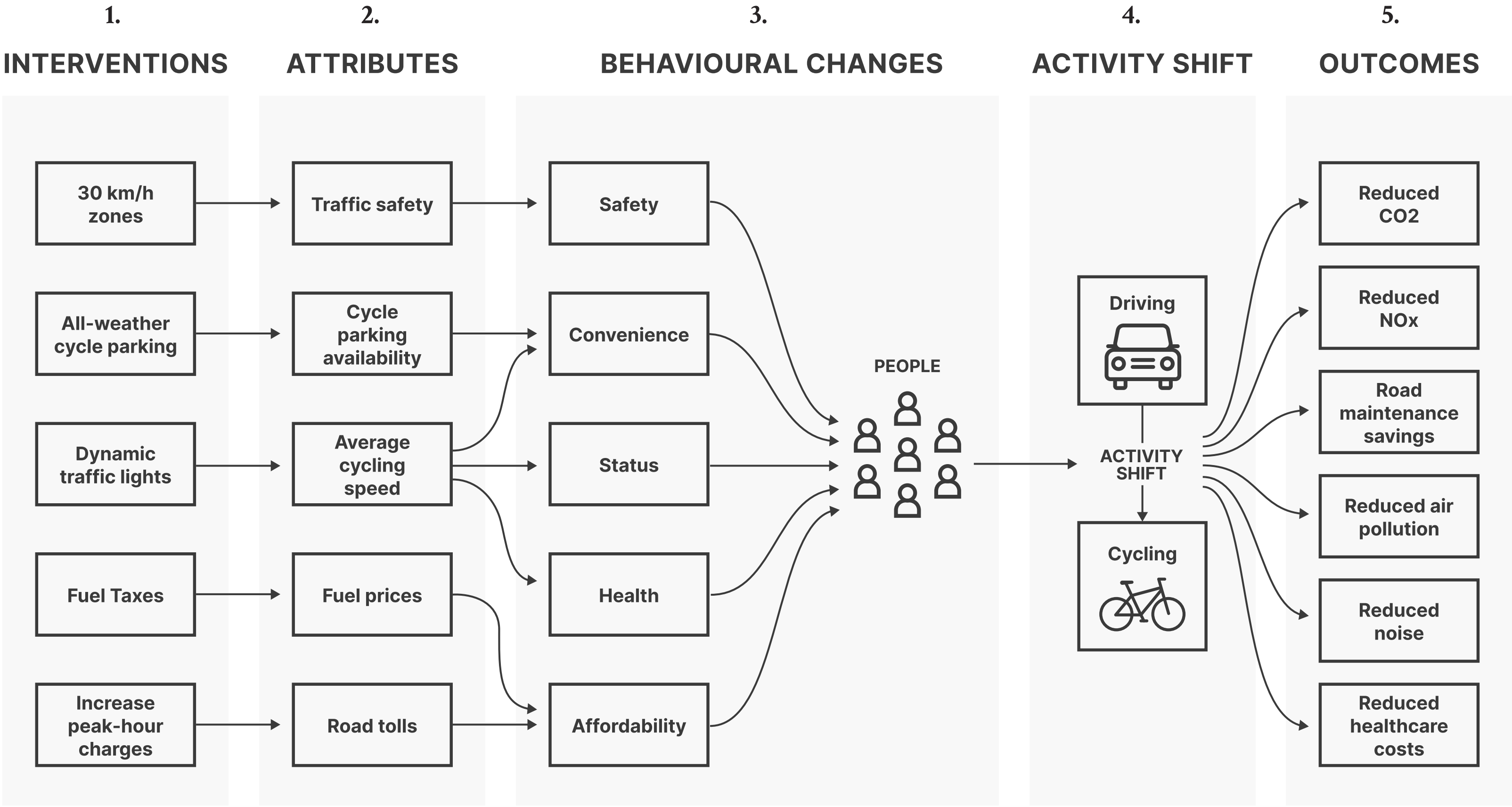


Figure 1. *Different interventions affect multiple city attributes, which affect multiple perceptions, which affect behaviours across different groups of citizens, leading to activity shifts and outcomes.*

This chain of causality, from interventions to outcomes, allows for the quantification and costing of every step along the way. Any additional co-benefits, such as health, noise reduction, or cleaner air, are also accounted for in the same way.

An iterative, scenario-based approach also reduces risk by solving key problems around data gathering. Administrations can begin to take action based on preliminary data, then work to refine that data and update their strategies over time. It allows for officers to test out assumptions and new solutions, changing course or doubling down based on the results.

To put this strategy into action, our work has shown a pattern: we can distil the outcome logic above into the following seven-step methodology for transitions. Each step is an iterative improvement of the scenario, build- ing confidence towards delivering the desired outcomes.

OBJECTIVES → ACTIVITY SHIFT → BEHAVIOUR → GAP → INTERVENTIONS → DECISIONS → FUNDING

1. **Objectives** – The first step of the process must be to understand the political goals, mandates, and objectives 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. It also includes an understanding of the current challenges facing society. Having a clear and comprehensive understanding of the situation gives freedom to act in later steps.

2. **Activity Shift** – The next step is to define the Activity Shifts that the administration will use to deliver its objectives, as well as their targets, and work backward to identify the tempo at which the transition needs to proceed.

3. **Behaviour** – It's now time to build out the scenario by identifying the attributes of the urban environment that can influence behaviour in the areas of those Activity Shifts, and people's perceptions of these attributes. This step gives an understanding of the preconditions of the transition – what it will take to create the behaviour change needed.

4. **Gap Analysis** – In this step the administration uncovers the gap* between its current status and already-planned interventions, and the desired outcomes. The basic question to answer is: will current plans deliver sufficient behavioural change to achieve the goals?

5. **Interventions –** Following the assessment of the gap, the inter- ventions needed to close that gap are identified. This creates a "to-do" list of formal decisions that need to be taken, and so the next step is to create a set of recommendations for decision-makers.

6. **Decisions –** Those recommendations must foreground the value gained through the proposed decisions, as well as the additional funding needed to deliver them. Analysis of the new interventions chosen by the administration, and the accompanying costs and changes in resource flow, will deliver this.

7. **Funding –** Finally, any additional funding needed and value gained through the transition are identified. When an administration reaches this stage, the process outlined in this paper will have established a well-defined and quantified plan with clear costs and benefits, which can be used to mobilise funding, bonds, and loans, and to identify the economic opportunities in the transition.

In reality, this process is anything but linear. It's iterative and cyclic. As policymakers and officials gather better data and learn more about what works in a local context, they can redefine the gaps and revisit the portfolio of interventions that they're working with. With scenarios, officials will make more informed assessments over time, redefine gaps and double down on the most effective interventions. Figure 2 is an example of how the process can branch, once Activity Shifts are set, into sub-processes as confidence builds towards the outcomes.

This outcome-focused scenario methodology delivers to stakeholders a fundable case for investment. It includes quantification of resource use, costs, timeline and co-benefits. It takes into account climate science, decision theory, dynamics modelling methods, sustainability assessment tools, future studies, and environmental policy and management. It's universal and can support processes within very different governance structures, whether in Shanghai or Skellefteå. It's also iterable as new information is gathered and circumstances change, ensuring that the administration's transition remains aligned with both its objectives and its realities.

* Many other processes begin with and focus solely on this gap. Experience has shown that it's better to embed a city transition into a comprehensive framework that delivers answers, rather than questions.

PART TWO

THE FRAMEWORK

The physical foundation

A society is a hub of activities, carried out by citizens to fulfil their needs. Needs fall into many categories – eating, keeping clean, working, travelling, communicating, socialising, recreation, and much more[4].

When someone does something to satisfy a need, we call that an activity (figure 3). All activities, ultimately, are physical and biological processes – examples include food being consumed, a house being heated, or a car being driven. Fundamentally, achieving a sustainable transition in a society means changing the activities that citizens use to fulfil their needs.

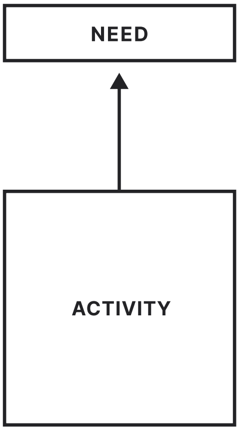


Figure 3. *An activity satisfies a need.*

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 house that is heated. If it's a car being driven, it's the distance travelled by the car. These operations can be tracked and recorded as data.

For the operations to fulfil the need, however, work must be performed. All activities require some kind of work to happen – it represents the chemical or physical transformation of energy required 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. All of these things can be tracked as data too. The framework refers to the unintended byproducts of the work as emissions. Emissions is a term that is normally used in connection with green- house 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 4.

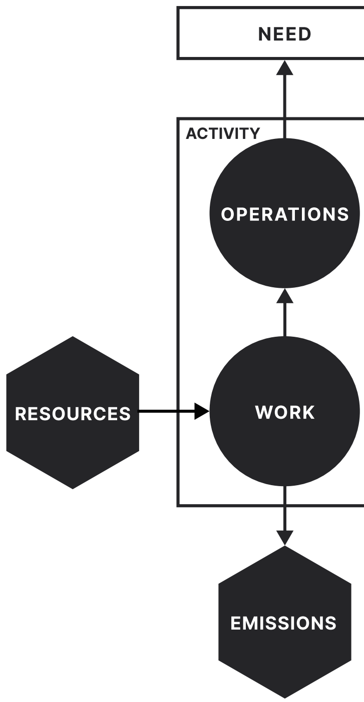


Figure 4. *Activities are broken down into operations and work. The operations are measured in operational units, while the work consumes resources and creates emissions.*

Seeing the transition through the lens of the activities that drive society unlocks confidence that it has a solid grounding in cause and effect, and can therefore be tackled bit-by-bit. This goes deeper than many of the current approaches that administrations use to tackle emissions. The implication of this activity-driven model is that all transitions in our society are ultimately dependent on shifts in our resource use.

The Activity Shift

Now that activities have been defined, we can look for opportunities to transition, or shift, from one activity to another while still fulfilling the same need. Many different activities can fulfil the same need, and this collection of activities forms the transition opportunity. Each shift is quantifiable, and is an opportunity to reduce resource use, or emissions, or both.

This can be modelled by wrapping the need, the two activities, and the shift from one to the other, into a single unit: the Activity Shift(figure 5).

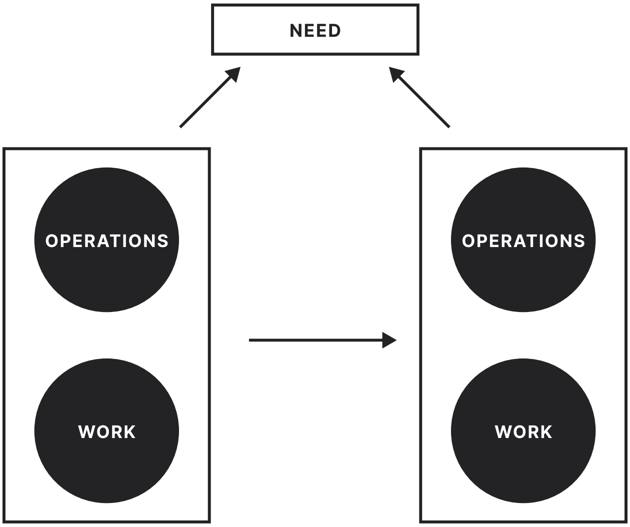


Figure 5. *An Activity Shiftconsists of a shift from one activity to another that both fulfil the same need.*

Ranging from the UNFCCC to individual municipalities, the terminology used to indicate mechanisms of change behind climate mitigation are vague and varied. For example, when the IPCC uses the term 'lever,' it is often unclear whether they are referring to a means of achieving something or the objective itself*. Because of the importance of this concept, this white paper attempts to establish a clear term and definition for an Activity Shift: a shift from a high-carbon activity to a low-carbon activity that both fulfil the same need.

* For some examples of how the IPCC uses the term "lever" see IPCC 2014 WG3 AR5 and IPCC 2022 WG3 AR6.

In other words, the Activity Shift is not the intervention or policy that precedes it. The Activity Shift is the "what", not the "how". Activity Shifts, when defined as in this way, fall into one or more of the following six[1] categories:

- **Type Shift:** Transitioning from a high-carbon type of activity to a lower-carbon alternative, like moving from an internal combustion engine to an electric drivetrain.

- **Resource Shift:** Shifting from one resource to another, like moving from coal to renewable energy sources like wind or solar.

- **Utilisation Shift:** Reducing the Utilisation of an Activity by cutting down the frequency or intensity of the activity itself or reducing the overall demand for that activity.

- **Work Efficiency Shift:** Improving the Work to Operations Efficiency, like retrofitting buildings with improved insulation and smart controls for energy efficiency.

- **Resource Efficiency Shift:** Improving the Resource to Work Efficiency by shifting towards more efficient use of a resource, like developing more efficient internal combustion engines to improve fuel efficiency.

- **Carbon Shift:** Enhancing or adding complementary Activities that increase the capacity for carbon sequestration. These can range from carbon capture and storage (CCS) to forest restoration and soil sequestration projects.

Managing shifts is at the core of the task of reducing emissions within society, and so these Activity Shifts sit at the heart of understanding the opportunities that a transition offers. An administration will typically start working with a subset of the most relevant Activity Shifts, perhaps 40-50 of them, which it will use to get a birds-eye view of the opportunities that they unlock.

Within this set, officials can look closer to see the details of each activity, as well as the economic opportunities of shifting from one activity to another, and the behavioural drivers relied upon to make that shift happen. Economics and behaviour are important. We'll come back to them shortly.

But first, let's look at how officials can quantify the activity shift within each Activity Shift.

The target and the tempo

Suppose an administration wants more citizens to shift from a "driving a car" activity to a "taking the bus" activity when fulfilling their "commute to work" need. The first step in making this happen is to choose to work on the Activity Shift "shift to public transport".

Then, the administration needs to figure out a target: the total shift required to achieve the desired outcome by a specific year. Targets can be expressed in many different ways. It could refer to the number of people walking and cycling, or a modality shift percentage, or vehicle kilometres. Targets should be expressed in units that the public can easily understand, though it's important that these align with the operational units of the activity being measured. For example, the operational units might be "passenger kilometres travelled by car/bicycle", but the target might be better understood as "percentage of people commuting by bicycle". This ensures that the target is not only actionable but also clear.

There are many ways to set targets, but the most effective approach is backcasting[5]. A forecasting approach starts with the present day and asks what might be possible, whereas backcasting defines a normative (i.e. desirable) future state, and then determines the pace of change required to reach it (figure 6).

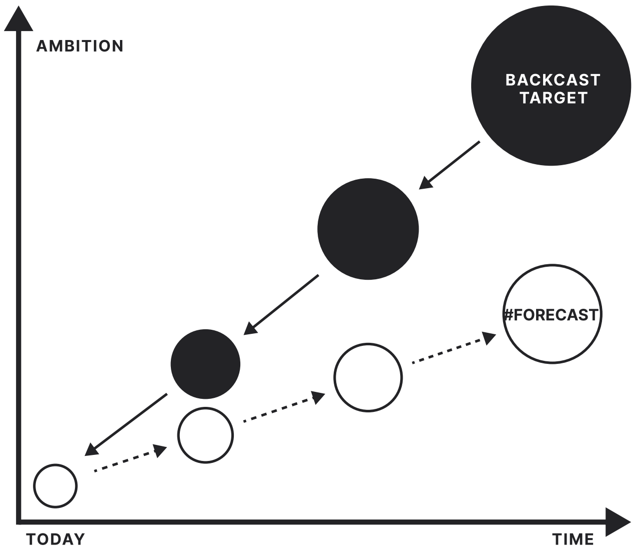


Figure 6. *Backcasting allows societies to be more ambitious in their transition.*

Setting a target provides two useful pieces of information. First, it provides the tempo of the shift – the pace of change required to reach the target. This gives clarity on the magnitude of the annual change needed, and can again be expressed in units that can be more readily understood by the public.

The backcasting method is particularly effective for setting targets for transitions, because it ensures that the targets set are both ambitious and achievable. When backcasted, the result of an activity shift over time should be a decrease in emissions, allowing strategists to assess the role that it will play in achieving society's emissions goals (see figure 7).

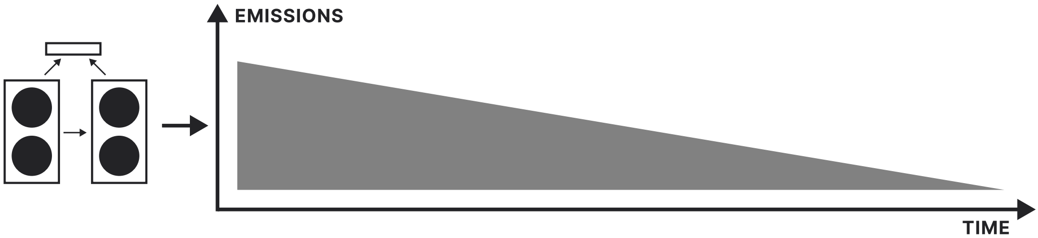


Figure 7. The result of an activity shift over time should be a decrease in emissions.

Second, a backcasting approach with targets also reveals vital information on resource use. When there is a shift from one activity to another, there is usually also a shift in the consumption of different resources. Backcasting a target allows officials, for example, to quantify the decrease in the consumption of non-renewable resources over time, as well as the increase in the consumption of renewable resources. This is especially useful in ensuring security of energy supply, which administrations are often responsible for, and is crucial in the development of energy plans.

The resource flow model

The full potential of an Activity Shift cannot be understood in isolation. Looking at the full set of chosen Activity Shifts, the interconnections between them start to become apparent (figure 8).

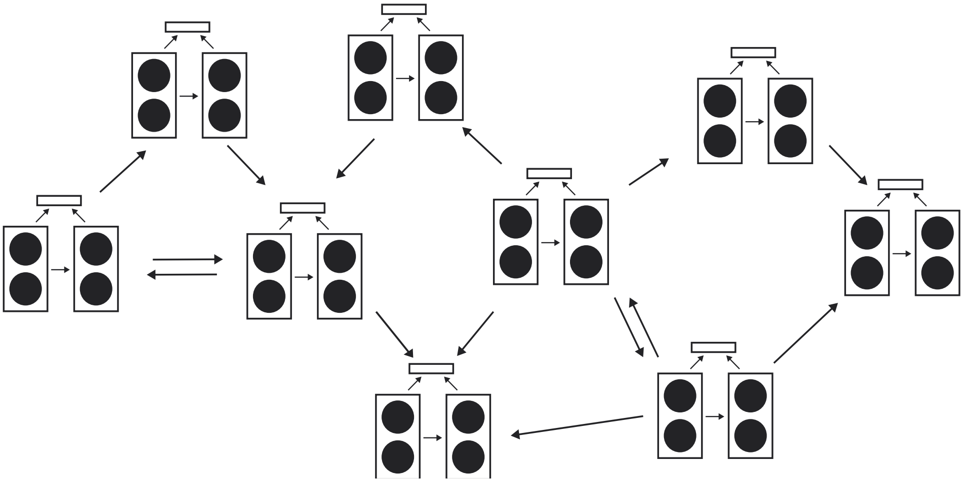


Figure 8. *Activity Shifts are interconnected through their shifting resource needs.*

By tracking the sum of the shifts in resource use for each Activity Shift, and the tempo of those shifts, it's possible to get a full resource flow model for an entire area – e.g. a city. This allows stakeholders to compare the effects of different Activity Shifts, and ensure that all targets are viable – that they fully account for changing resource needs over time.

For example, a full resource flow model would show that switching to electric cars becomes significantly more effective at reducing emissions if a city reduces the amount of fossil fuels in the electricity supply at the same time. Not only that, the emissions produced by those cars can be quantified at every stage of the transition, as well as the resources (in this case, electricity) that those cars will need to operate. Doing this allows us to get a full picture of changes in use of electricity and other resources throughout society.

The interconnections revealed by the resource flow model help to assess an administration's full set of Activity Shifts and their targets together. Understanding the supply and demand of resources over time, and making sure that they can be met, ensures that targets can be both ambitious and realistic at the same time.

The economic model

It's time to go back to the activity and introduce a new piece – stock. Stock represents the durable objects used to enable the operations of an activity, like vehicles, buildings, industrial machinery, or infrastructure pipes that support the operations essential to citizen needs. The distinction between stock and resources is critical – stock serves a purpose repeatedly without being consumed. A car, for example, can embark on many journeys. This is different to resources, such as the fuel for the car, which are used up by the activity.

Different types of stock come with different lifespans. A car typically serves its purpose for around 15 years before it requires replacement, while a house can stand and be used for a century or more. These lifespans are important to consider when planning, alongside the fact that they can be extended with proper maintenance.

By incorporating stock into the framework, there is now a complete model of an activity (figure 9). The physics and environmental impacts are accounted for, and now the economics are too. This approach allows officials to assign costs and values not just to the operations and resources consumed, but to the emissions of the activity and the stock that enables it.

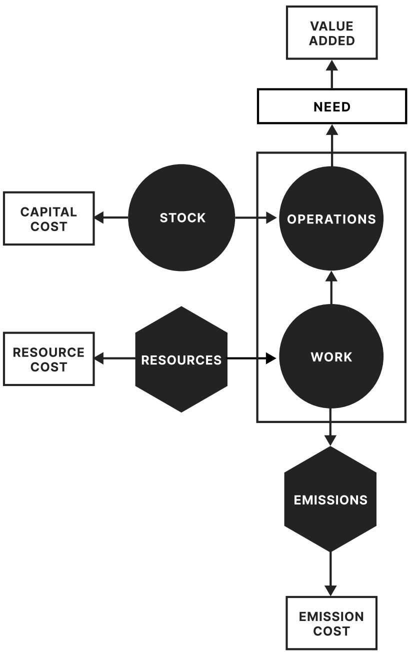


Figure 9. *The economic model shows how to attach costs and value to all parts of an activity.*

It means officials can make informed decisions about investments, maintenance, and lifecycle management of the assets that play a pivotal role in the transition. This informs any municipal climate investment plan.

Understanding the importance of stock within the framework also paves the way for new economic strategies. It invites opportunities around circular economics, where stock is optimised for longevity and reuse, and for the adoption of sharing economies where the utility of stock can be maximised across a population, improving the efficiency of production.

Co-benefits

Understanding the economic layer also allows an administration to quantify the co-benefits associated with specific Activity Shifts. Different parts of an activity have different co-benefits associated with them, each bringing its own opportunities.

For example, within the emissions part of an activity, co-benefits could include noise reduction and cleaner air, which benefit public health and the environment. Within the operations part, an Activity Shift that encourages active travel, for example, might lead to lower obesity rates and/or safer streets. The stock component, particularly in sectors like housebuilding and green energy infrastructure, can bring co-benefits that include employment growth, which in turn creates jobs and drives economic development. Finally, in the resources part, choosing the right Activity Shifts can lead to co-benefits that include efficiency improvements, cost savings, and energy independence.

In addition to the full resource flow model, this new economic layer of understanding now unlocks a financial dimension which allows for analysis of capital expenditure (capex) and operating expenses (opex). This is crucial for building a solid financial case for a rapid transition away from high-carbon activities (see figure 10). It is also useful for supporting the climate investment plans, climate budgeting, and other policy and governance documents.

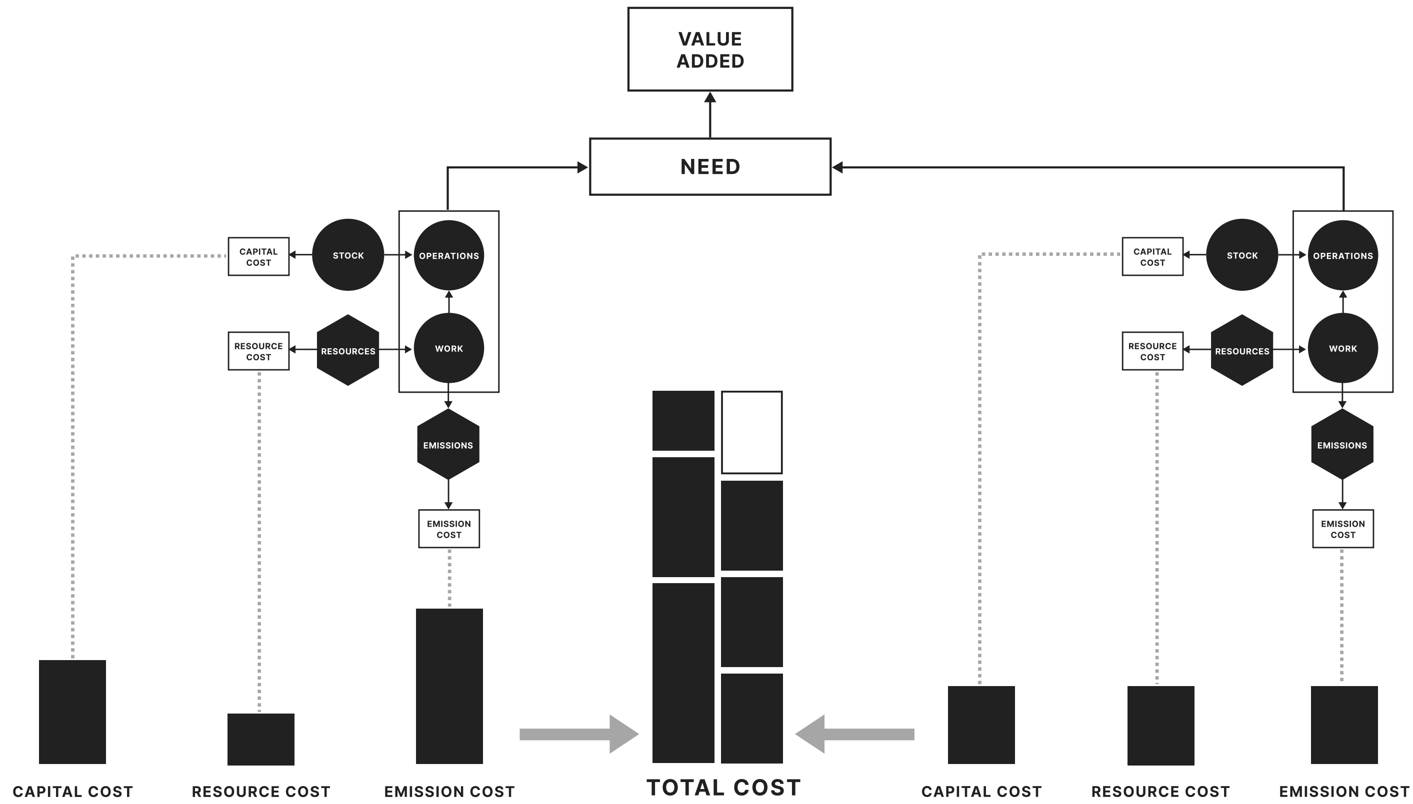


Figure 10. *Comparing total costs between activities helps make the case for an activity shift.*

From targets to scenarios

With the addition of these new layers, it's now possible to backcast the targets for the entire set of Activity Shifts to start to create a full scenario which delivers the outcomes that policymakers want – across citizen health, economic prosperity, quality of life, and emissions (figure 11).

The first building blocks of a scenario are a set of Activity Shifts with targets and tempos, and quantification of the interconnections between the targets and resources within that scenario. This creates a "what if" starting point that allows for changes to be tested to see how their effects ripple through the system.

Multiple scenarios can then be created and then explored, and assessed according to local circumstances and political priorities. Costs can be optimised and assumptions tested, and different eventualities can be planned for. Scenarios can also be updated and iterated over time to reflect changing economic, environmental and political conditions.

When doing economic modelling on the shift from one activity to another – say, from car to bus – we get a change in stock costs, resource costs, emissions costs, and externalities. In this change, there are both oppor- tunities and risks. Any opportunities must be assessed as reasonable and achievable

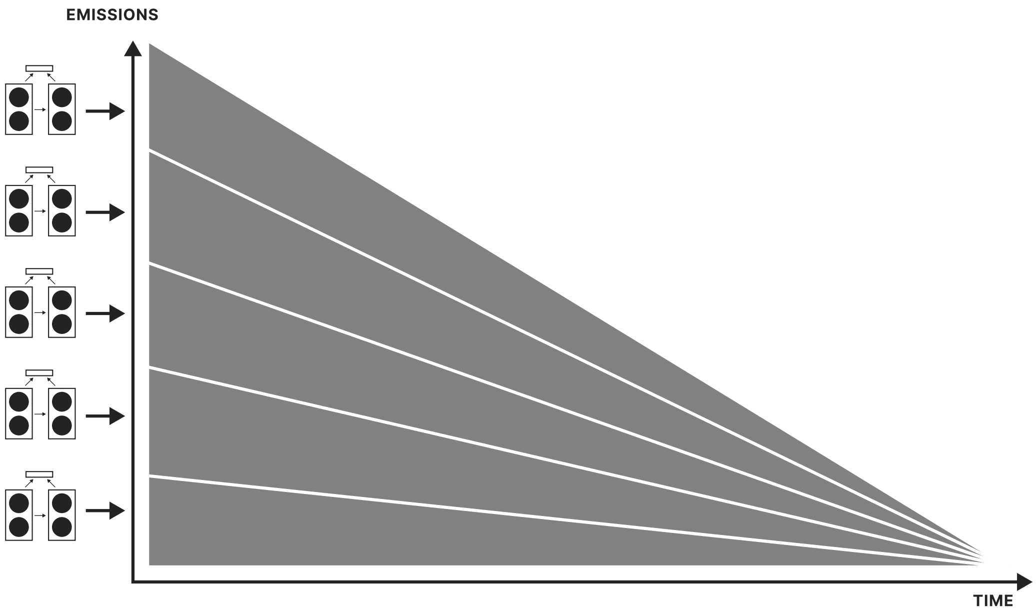


Figure 11. *A scenario describes a "what if..." – a collection of Activity Shifts and their targets and tempo, along with a resource flow model and economic model of their interconnections over time.*

– if a city needs 600 apartments to be retrofitted each year, with only 100 builders available, the choice is not reasonable. Or perhaps a city sees an opportunity in delivering a recycling program targeting a 30% waste reduction in the next five years, but the existing recycling infrastructure, designed three decades ago, cannot process more than a 15% reduction. What is physically and technologically possible is also not to be conflated with what is politically possible.

It is only at this stage, after creating a scenario with Activity Shifts and a tempo – that we can assess a 'what if…' with time in mind. This creates the limitations needed to highlight where resources must be focused. Whether influenced by Doughnut Economics, working to stay within Planetary Boundaries, or generally striving for a circular economy, the conclusion is the same: resources are limited. The iteration of Activity Shift scenarios allows a city to prioritise, weig- hing between options like bicycle paths, retrofitting, or new infrastructure.

This is where we move from the "what" of the Activity Shift to the "how" – the interventions and policies that can deliver the activity shifts required. Are enough interventions planned? What stands between these interventions and the desired outcomes? It's time to dig deeper into behavioural factors in the outcome logic.

From interventions to outcomes

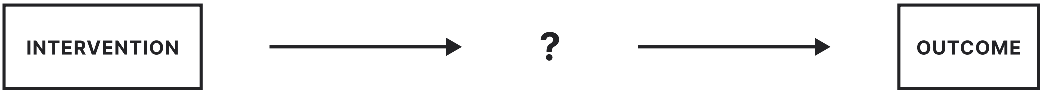
We now have one or more scenarios, but how do we get there? What decisions need to be made today to realise those scenarios tomorrow? Which types of interventions will deliver the desired outcomes? These questions are common in an administration, for good reason. To find some answers, let's revisit the outcome logic described earlier in more detail.

So far, we've talked about targets and shifts, resources and stock, operations and emissions. But we haven't talked very much about people, except when discussing their needs. Let's take a closer look at the population, and see how human behaviour can be integrated into this framework.

In the context of transitions, human behaviour is fundamentally about choosing. Let's define behaviour change: if a behaviour is a choice of activity to meet a 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, reflects a behavioural change.

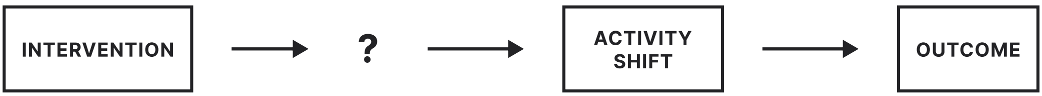
It's notable that the term "behaviour change" is almost always used to refer to daily decisions made by individual citizens, but it should be understood much more broadly than that for this model to be effective. It should also encompass longer-term decisions made by citizens, like whether to install a heat pump or retrofit their home, as well as organisations and administrators making changes to their policies or processes. An administration deciding to install a carbon-capture-and-storage system in their waste-to-energy plant is changing its behaviour too. It all boils down to humans making decisions, small or large, over what activity to choose to fulfil a given need.

Scenarios include targets, and backcasting those targets tells a society how fast it must shift to get there. But reaching targets inevitably requires people to change their behaviour, making new choices. To take this into account, let's more closely examine some of the concepts introduced earlier – particularly outcomes, interventions, city attributes, and perceptions.



An outcome is what we want to see happen. It is the result of a shift from one activity to another, as a consequence of people changing their behaviour. Outcomes might include cleaner air, reduced CO_2 emissions, or improved health.

In order to achieve an outcome, administrators influence the society through interventions. An intervention is the result of a formal decision that leads to a purposeful change in the urban environment. Examples might include an investment in safe bicycle storage at a station, a policy that allows working from home at least once a week, or the launch of an information campaign on the costs of heat pumps.



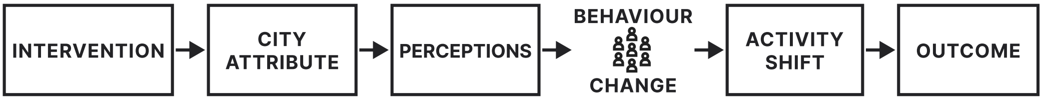
Changes in the urban environment drive changes in human behaviour, which in turn drive outcomes. A city attribute is a property of that urban environment that encourages or discourages specific behaviours among a population. It is real and measurable – like the average distance to a bus stop, or the cost of buying a ticket, and it is also expressed in a way that allows comparisons between one urban area and another.

While interventions are the main options available to officials who want to achieve changes in the urban environment, it can also be changed unintentionally by other factors – such as macroeconomic trends – only some of which will be in control of the authorities.

Between a city's attributes and activities shifts lies behaviour and the co-creation of this method with administrations, behaviour has been brought up as a major focus. So let's look closer at the behaviour change category and break it down into the public perceptions and what people do as a result of those perceptions.

Perceptions are public perceptions of city attributes that drive behaviour, distilled down into five categories: safety, convenience, affordability, health, and status. It's worth noting that perceptions differ between socioeconomic groups, gender, race, age, disability, and many other factors, and while we've been talking about this framework applying to a society in a region or a city, it can also apply to a neighbourhood or even a single housing development.

These perceptions are what influence the behaviour changes that truly drive shifts from one activity to another. We change our behaviour when the alternative is perceived to be safer, simpler, more affordable, healthier, more socially accepted, or a combination of these factors.



Adding all this up, we arrive at the outcome logic described above, where an intervention alters a city attribute, a city attribute influences public perceptions of the urban environment, perceptions influence behaviour, and a behavioural change creates an activity shift, which delivers an outcome. This logical flow allows us to measure and cost the behavioural change required to turn a scenario into reality. It describes the full chain of causality between interventions and outcomes. It makes assumptions clear, improves confidence, and allows interventions and city attributes to be iterated over time based on the progress towards its desired outcomes.

In practice, though, it's rarely as simple as a straight line – different interventions can affect multiple city attributes, which affect multiple perceptions, which affect behaviours across different groups of citizens differently (figure 12). Some of those citizens change their behaviours, yielding activity shifts that deliver outcomes.

There are various models for behaviour change. These include concepts like the COM-B model, or the nudge theory, that exist to understand behaviour change. Administrations often use these models to explore and encourage behavioural shifts. Despite the messiness of human behaviour, and the chosen model aside, city attributes remain constant inputs to these models. In essence, regardless of the model one adopts, human behaviour boils down to choices.

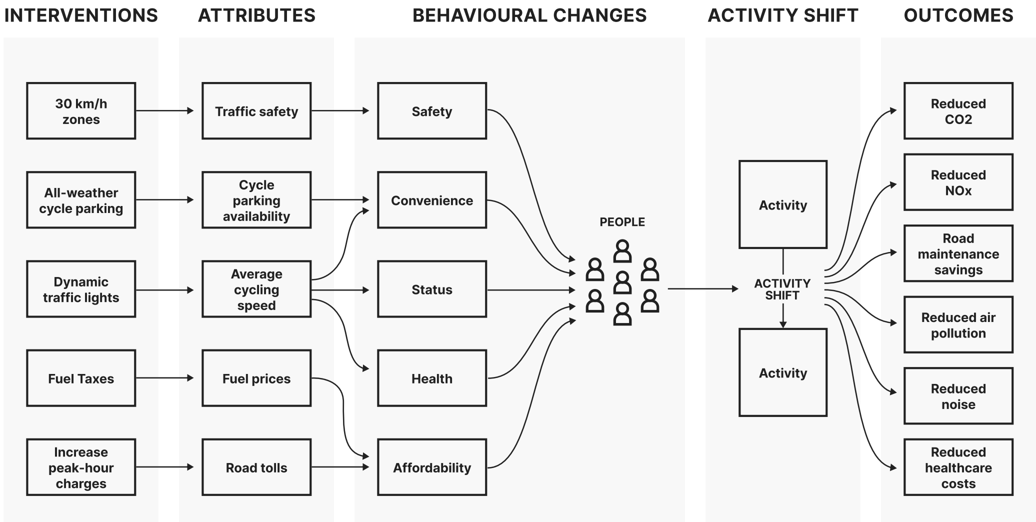


Figure 12. *Different interventions affect multiple city attributes, which affect multiple perceptions, which affect behaviours across different groups of citizens differently.*

Transition Elements

With the outcome logic laid out this way, 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.

To operationalise an Activity Shift, it's helpful to wrap up everything involved in each instance of an outcome logic into a comprehensive data model, rooted in the IPCC's 2006 report on Guidelines for National Greenhouse Gas Inventories[6]. We call this package a Transition Element. Transition Elements contain all the data an administration needs to test and iterate scenarios, with buckets for every step in the outcome logic – for interventions, for city attributes, for perceptions, for behaviour, for Activity Shifts and for outcomes. Feeding data into a Transition Element assesses potential outcomes of the relevant Activity Shift.

To kickstart the work of officials, a Transition Element contains a set of blueprints that serve as "useful defaults" for data that an administration may wish to collect. This includes blueprints for useful interventions, blueprints for relevant city attributes, and models for its Activity Shift. These blueprints can be altered, of course.

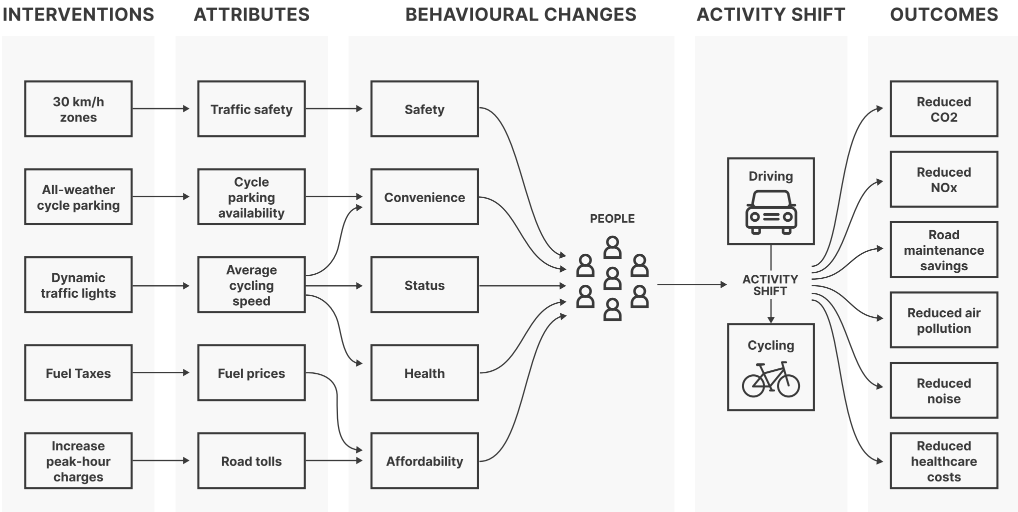


Figure 13. *A Transition Element for an Activity Shift where people are shifting away from commuting by car to cycling.*

To help understand this, it's useful to look at an example. Figure 13 shows a Transition Element where people are shifting away from commuting by car to cycling instead, i.e. the outcome logic for this Activity Shift. It includes a selection of example interventions, city attributes, and outcomes.

Collecting together all of the possible Transition Elements that administrators can use to deliver their transition creates the Periodic Table of Transition Elements (figure 14). We can think of it as a periodic table of Transition Elements, each a collection of data associated with a specific Activity Shift and its outcome logic, and each based on quantifiable physics, organised into different sectors, like transport, waste, and energy.

The Periodic Table of Transition Elements contains more than 100 interconnected Activity Shifts. These are based on descriptions in IPCC 2014 WG3 AR5 and IPCC 2022 WG3 AR6 and have been further developed through collaboration with local and national authorities, such as Sweden's Climate Policy Council, Energy Agency and Environmental Protection Agency.

The development of the Periodic Table of Transition Elements marks a significant milestone in modelling efforts, but it's not the final goal – it's merely a starting point for ongoing development. It will continually evolve to reflect new data and experiences. Administrations, experts, and other stakeholders can contribute – enhancing its utility as a guide to urban transformation.

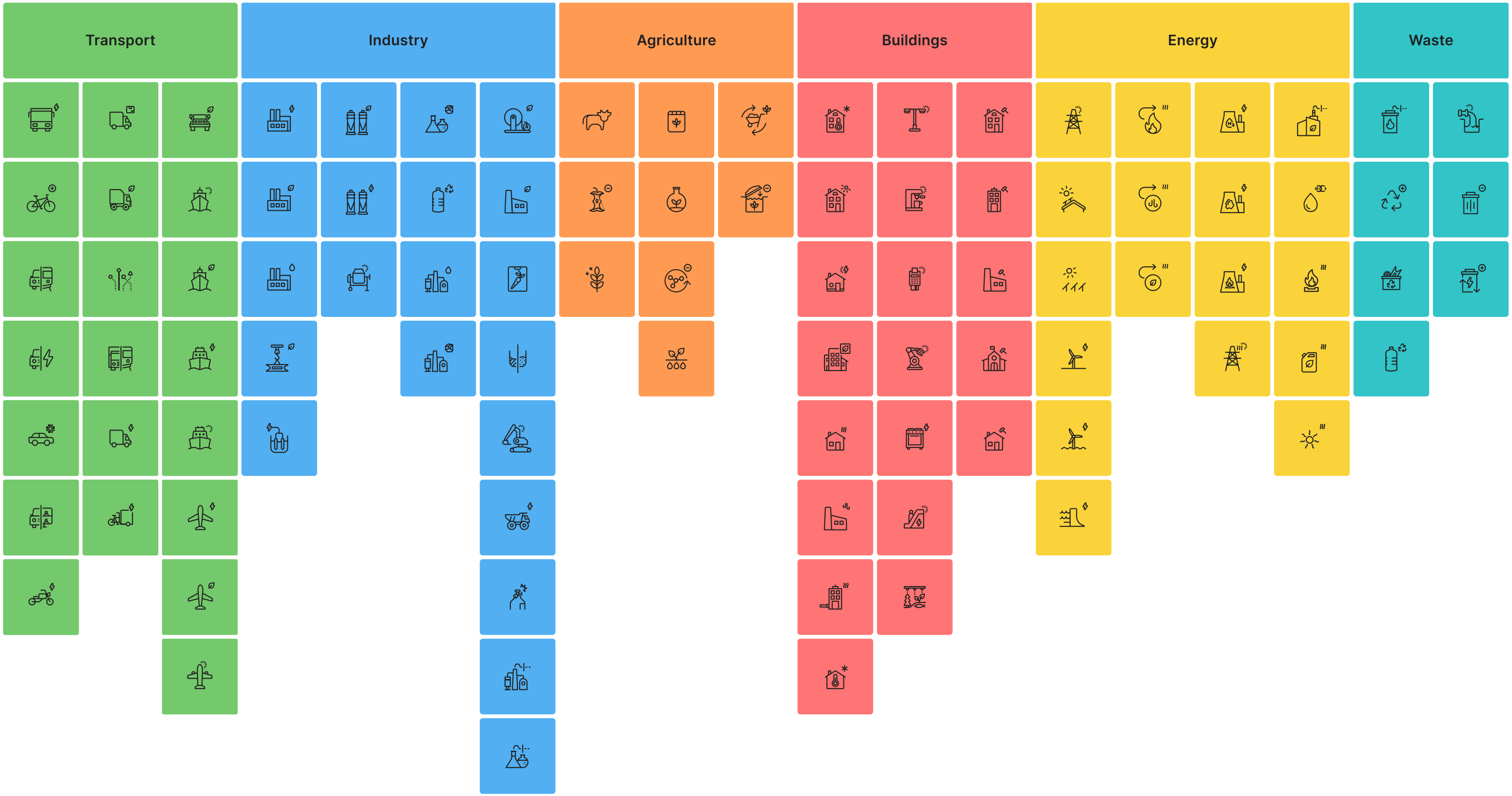


Figure 14. *The Periodic Table of Transition Elements.*

PART THREE

THE PLATFORM

The co-created framework presented in this white paper shows how to connect the dots in a transition. It helps to structure information and data. But to bring the theory to life, climate planners need a way to implement it across locations and sectors. Since 2018, we've worked alongside diverse administrations to develop the ClimateView Platform for this very purpose.

With all the data in one place, the platform is where theory becomes practice. It is where an administration defines its objectives, selects the Activity Shifts it'll use to reach them, identifies the interventions it takes to close the gap between ambition and reality, tracks the progress of those interventions and the resulting policy iteration, and generates the evidence base necessary to take decisions and report to funders.

Many administrations hold off on taking action while they wait for better data – on more precise emissions estimates, or projections of future changes in the energy mix. Instead, it's enough to consider what level of data precision is sufficient to make informed decisions, what evidence base is required to begin to take action, and what kinds of data have the greatest operational value. Productive work can be done even with imperfect data.

Helsingborg, a city in southern Sweden, has had great success working iteratively – since 1990, the municipality has combined innovation and sustainability to reduce its emissions by 52%. The iterative methodology that the platform is built on has allowed cities like Helsingborg to sketch out scenarios and test outcomes of different interventions with data that's "good enough" – perhaps older, or collected at a national level. The platform has then helped officials to identify where more accurate data would be valuable, and make new plans once that data is collected and integrated. Every change is logged and can be reverted. As one civil servant in Helsingborg said "[the important thing is] that other stakeholders in Helsingborg can contribute and participate in the development. We'll learn along the way."

Seven iterative steps

We've seen this co-created method, framework and platform used in as many ways as there are places. There is, however, a pattern across municipalities, whether in Northern Europe or the US Midwest. Cities tend to be able to reach their outcomes in a more systemic way when they follow iterative steps. These seven steps start with setting the objectives, identifying the Activity Shifts, establishing the behaviour changes needed, as well as assessing the gap, and based on this, making recommendations for interventions and decisions that – in extension – lead to funding (figure 15). The whole time, this outcome-focused approach is underpinned by scenarios.

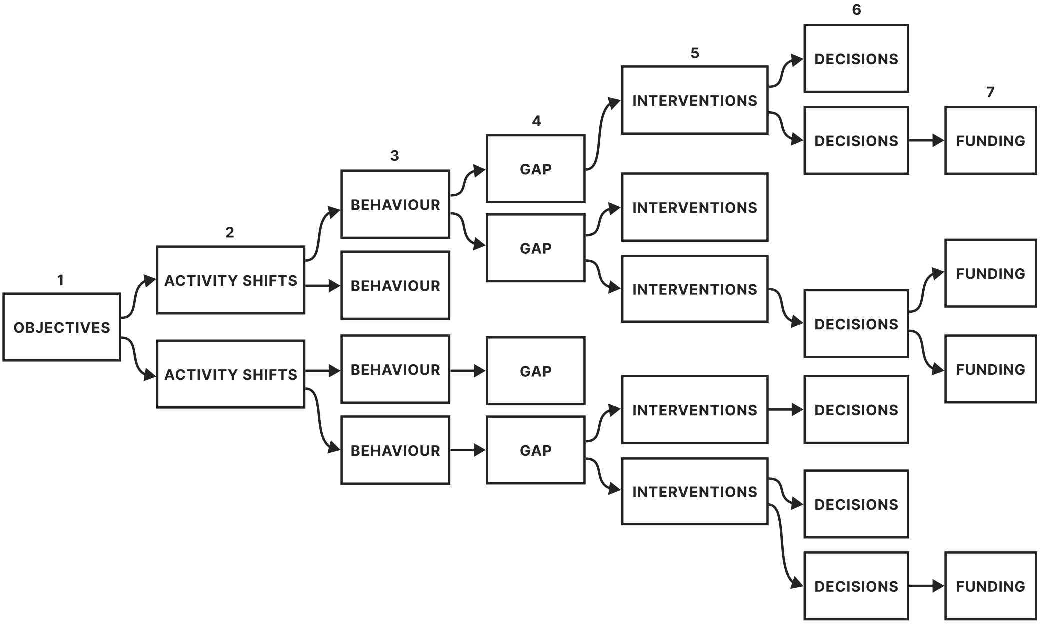


Figure 15. *The seven steps bifurcate into separate workstreams, all underpinned by the Dashboard and scenarios.*

Objectives

When defining objectives, the platform helps climate planners to understand where emissions are coming from, and break them down into different activities in a hierarchy. It visualises climate goals, business as usual, and the difference between the two. Working from a solid foundation of data ensures that objectives are realistic and appropriate, while still being ambitious. As such, the "Inventory" section of the platform should be the first place to be populated. This allows for a comprehensive view of current emissions, energy use, environmental impacts, and economic activities.

Understanding the different ways that data flows through the platform is key to understanding its effectiveness. Activity data tracks what is causing emissions, and how Activity Shifts can be used to reduce those emissions. Socio- economic data tracks the city's attributes and how they're perceived. Out- come data shows what the results of a shift might be, in terms of emissions, resources, economic opportunities, and co-benefits. All of these things are supported by the fundamental model of the Transition Element (figure 16).

Copy of ClimateVille / II - Transportation / II.1 - On-road / Personal transport

Personal transport

2021

Name	Operations	Energy intensity	Energy (kWh)	Resource	Emissions (kt)
Petrol cars	11,163,987,603 Vehicle km	0.7228 kWh / vehicle km	8,069,330,239	Resource mix	2,500.000
Diesel cars	5,448,573,743 Vehicle km	0.6607 kWh / vehicle km	3,599,872,672	Resource mix	1,130.900
Gas cars	0 Vehicle km	0.857 kWh / vehicle km	0	Resource mix	0.000
LPG cars	0 Vehicle km	0 kWh / vehicle km	0	Liquefied petroleum gas (LPG)	0.000
Pure electric vehicles	44,760,000 Vehicle km	0.2262 kWh / vehicle km	10,124,712	Electricity	4.926
Petrol motorcycles	0 Vehicle km	0.46265 kWh / vehicle km	0	Resource mix	0.000
Electric motorcycles	0 Vehicle km	0.0225 kWh / vehicle km	0	Electricity	0.000
Diesel buses	0 Vehicle km	3.26 kWh / vehicle km	0	Resource mix	0.000
Gas buses	0 Vehicle km	6 kWh / vehicle km	0	Resource mix	0.000
Electric buses	0 Vehicle km	2 kWh / vehicle km	0	Electricity	0.000
Active travel	2,700,000 Person km	0 kWh / person km	0	n/a	0.000
Total			**11,679,327,624**		**3,635.826**

Transportation

Petrol cars

	Reference	Estimated allocation per stakeholder 2021-2050			
	Total 2020	Citizens	Property owners	Healthcare providers	City council
Capital expenditures					
Vehicle purchase	2121 Million EUR	70 %	0 %	0 %	
Operational expenditures					
Vehicle maintenance	1894 Million EUR	70 %	0 %	0 %	
Fuel	1699 Million EUR	70 %	0 %	0 %	
Negative externalities					
Particle emissions	23 Million EUR	2 %	0 %	80 %	
NOx emissions	70 Million EUR	2 %	0 %	80 %	
Accidents	479 Million EUR	2 %	0 %	80 %	
Noise	63 Million EUR	40 %	0 %	15 %	

Figure 16. *Analysing objectives through the platform.*

Activity Shifts

When a city is selecting which Activity Shifts to use to achieve its goals, the platform can simulate the effects of every Transition Element in the Periodic Table of Transition Elements. The "Scenario" feature and the Dashboard let city officials see their options in every sector, allowing them to not only choose between different "what if ..." visions of the future, but to communicate the reasoning and the outcomes of those choices to other stakeholders.

Dortmund in Germany was once a stronghold of the mining and steel industry but the city is now working towards net-zero emissions by 2035. Using the platform, the city has created a climate action plan focused on Activity Shifts within mobility, housing and the economy – sectors that each represent about a third of the city's emissions. The platform allows for ongoing assessment and iteration of climate interventions, supplying useful data for decision-makers.

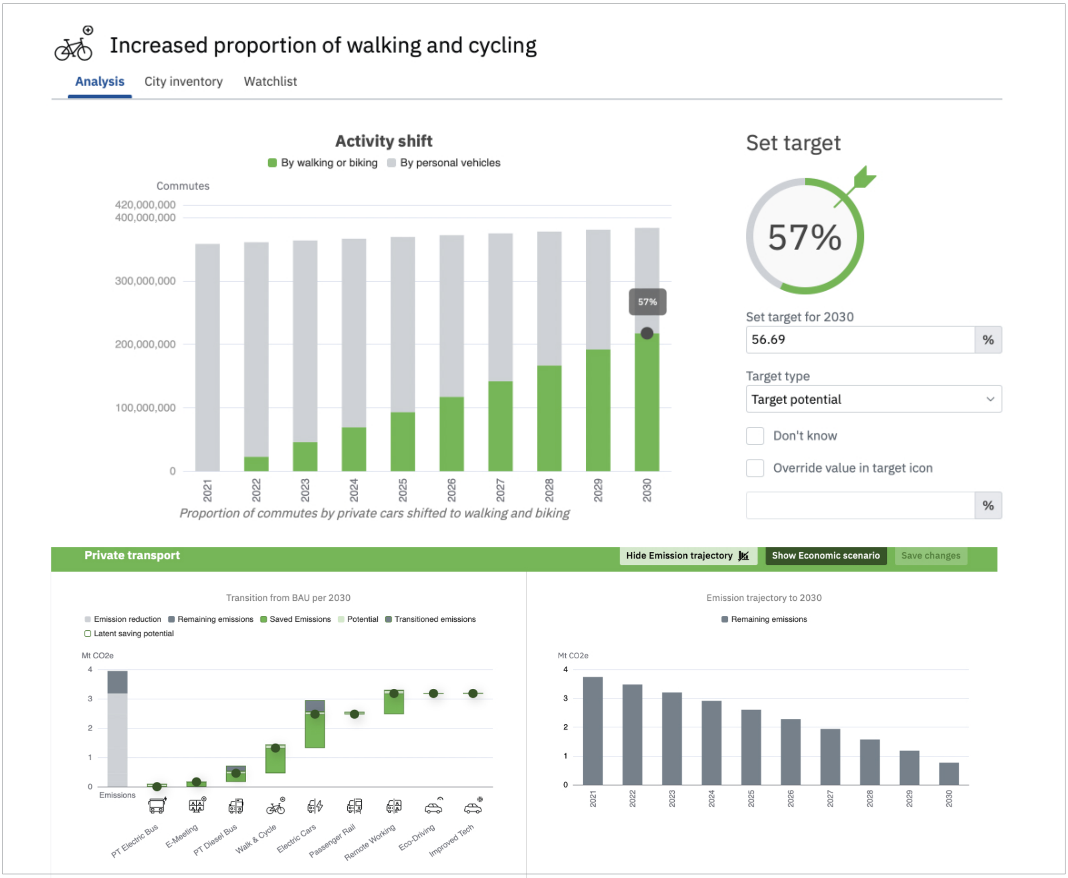


Figure 17. Activity shifts and targets seen in the platform.

Behaviour & gap

We've now established the "what". Time to move into the "how". When backcasting targets to establish the pace of behavioural change necessary to achieve them, the platform shows how different city attributes are affected by different interventions, and helps the city to understand how these could affect the gap between current interventions and future goals. It allows administrations to see progress over time and whether the transition is on track – building a chain of reasoning based on data.

At this point in the process, administrations continue to build their scenarios with the "Action" module – understanding behaviour change, gap analysis, as well as the actions themselves. This feature connects interventions with objectives through the outcome logic, helping assess the shift of perceptions and behaviour needed (figure 18).

When it comes time to implement new policies to close that gap, the plat- form helps to establish common ground between different viewpoints. It helps to turn the commonly-heard "Are we doing enough?" from a political question into a more neutral one, where the answer is data-informed and based on the best-available figures. This step, focusing on the gap, still takes place in the "Action" module, outlining the difference between the current status and the objectives. This lets administrations identify where more effort is needed.

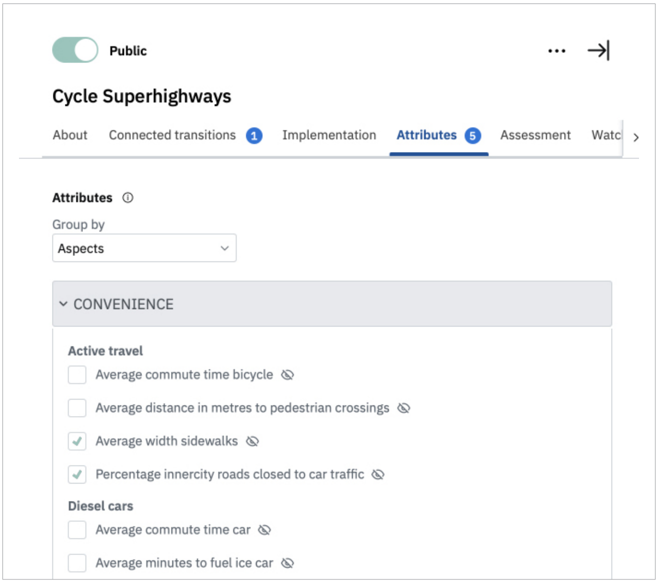


Figure 18. *City attributes seen in the platform.*

Interventions

Reaching outcomes in the transition hinges on well-informed decisions, leading to interventions that influence the necessary Activity Shifts. These interventions are supported in the "Action" module too, supporting the development of a clear plan. This part of the platform provides decision-focused insights, outlining the necessary steps and formal decisions required to achieve the identified objectives.

As one civil servant in Dortmund puts it: "While climate action plans are necessary, they can often be inflexible. We see the main potential for the platform to be allowing us to evaluate the outcome, find what's working or not working and adapt our plans accordingly. With the platform, interventions can be integrated on a continuous basis, allowing us to keep track of our progress in the coming years and make changes based on new data, new ideas and evaluation of current interventions." Dortmund – an EU Mission City – makes its data and findings publicly accessible. This choice was made both for transparency, and to contribute to wider understanding of climate solutions in society.

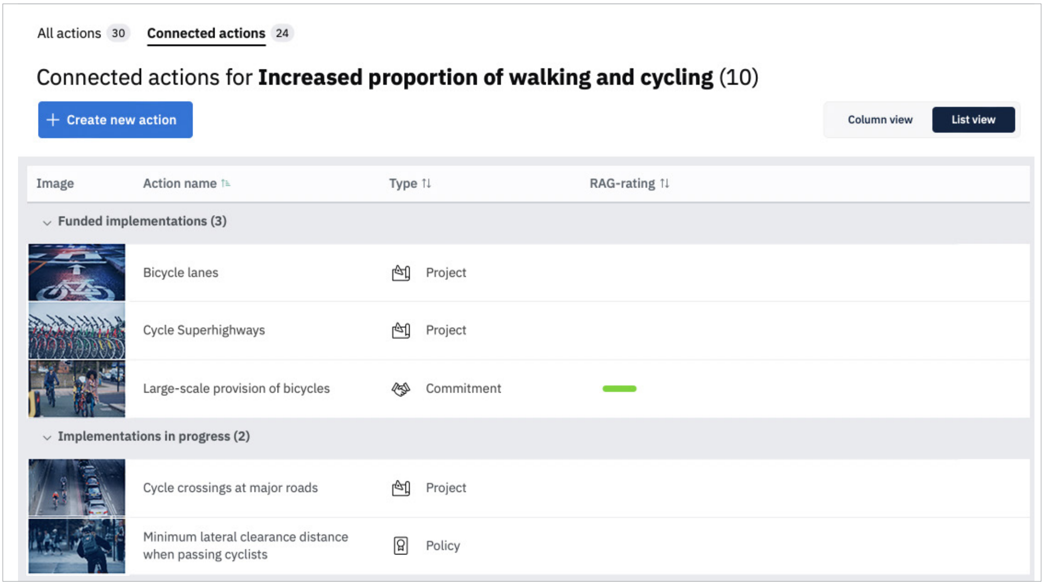


Figure 19. *Interventions seen within the platform.*

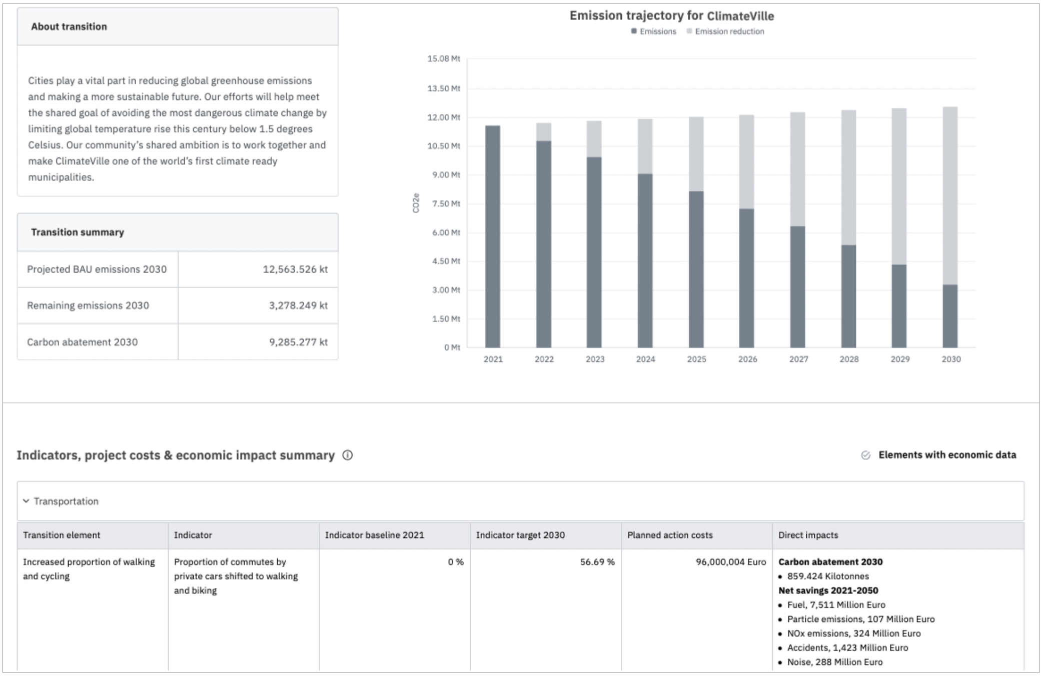


Figure 20. *Emission trajectories and indicators in the platform.*

Decisions

The data model of the outcome logic – the Transition Element – means that specific recommendations to decision-makers can include a causal chain of reasoning, as well as the quantification of how the proposed changes will affect the city's emissions, resource flows, and finances. The architecture of this data model allows stakeholders to get a better understanding of assumptions and confidence intervals, and it includes co-benefits like health, noise reduction, and cleaner air. This comes in handy in processes like climate budgeting – an increasingly essential tool in local governments – which merge climate considerations with financial planning, as seen in cities like London, New York and Oslo.

Early indicators show progress towards objectives (figure 20), growing confidence towards expected results and allowing for scenarios to be iterated upon over time based on those results, making for a stronger case. The platform makes detailed analysis of the proposed actions, including assessments of cost and resource changes, available through the "Economic" module.

For example Nottingham has set a goal to become the United Kingdom's first carbon-neutral city by 2028, and since 2005 it has reduced its per-capita emissions by 52%. The city uses the platform to monitor its data and iteratively improve its strategy, helping city officials to revise Activity Shift targets based on new information and coordinate decarbonisation efforts across different sectors like transport and buildings.

One officer said: "The platform has shown us the changes that need to be made within key sectors, such as transport, energy generation, and decarbonisation of our built environment which make up the biggest emissions percentages in the city. We now understand the relative scale of emissions changes within these different themes. This insight will help us focus on interventions that will enable us to decarbonise faster."

Funding

When reporting to funding bodies the platform makes it straightforward to export the evidence needed for accountability processes. Outcome measurement is simple, as all the data is built into the model, and it's possible to export any spreadsheet, chart, or PDF, feeding into strategies, budgets, energy plans, or climate action plans (figure 21).

In Mannheim, a large industrial city in Germany which aims to shut down its coal power plant by 2033, the platform is being used for funding-related initiatives, supported by the "Economic" module as well as the "Investment Report" feature. Officials are able to identify the financial requirements and value gains from the transition, and make adjustments based on performance figures, costs and benefits, as well as new trends that emerge over time. This has supported the creation of Mannheim's climate investment plan, as part of its status as an EU Mission City.

This feature facilitates the mobilisation of funding, bonds, and loans. It also helps to uncover economic opportunities in the transition, such as the Inflation Reduction Act.

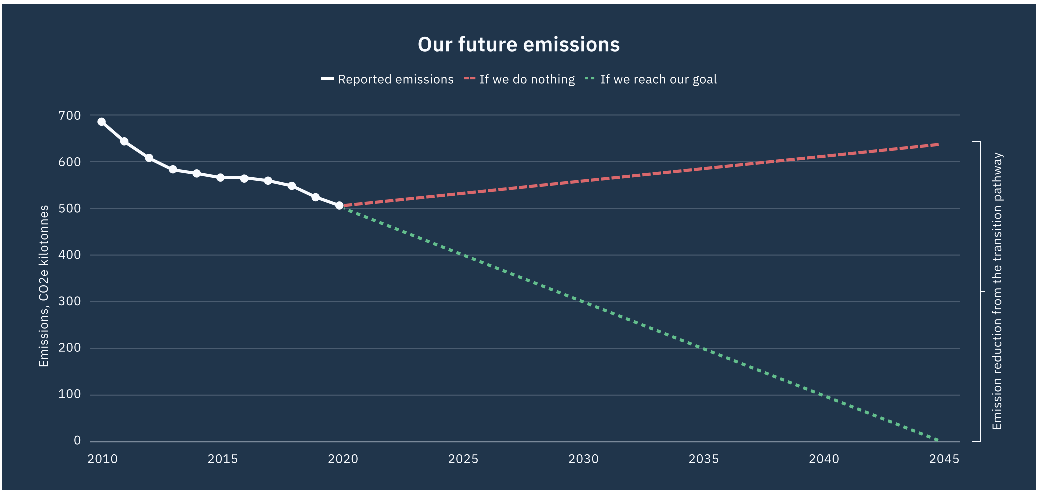


Figure 21. *Any chart in the platform can be exported, as well as the data behind it.*

Dashboard & monitoring

The platform could be described as a window, with its central Dashboard as the glass. On the one hand, it is a place for the administration's internal stakeholders to get on the same page on what's happening out in the city. But it is also the place where the external stakeholders – the citizens – get an overview of the work being done on the transition. It is transparent.

In Tyresö, a municipality in the archipelago of Stockholm, this transparency has allowed discussions led by evidence and data to be held, even in local schools, encouraging citizens to consider various scenarios for the future of the town. Dortmund, Heidelberg, Kiel, Eskilstuna, Mannheim, Ravenburg, Bristol, and Dundee are also among the cities which have made their transition data fully available for the citizens, though administrations always have a choice in this. The Dashboard allows actors to retain a focus on outcomes. Starting from the setting of objectives and selecting of Activity Shifts, it visually represents possible scenarios, and iterations are reflected throughout the behaviour, gap and actions phases, becoming a real-time reflection of progress.

The Dashboard's visual representation of the trajectory aids data-informed decisions and monitoring (figure 22), and when working to find funding for the transition it shifts focus to the Climate Investment Plan, for financial strategies and anticipated costs and benefits, solidifying accountability in budgeting, funding, and finance-related documentation.funding, and finance-related documentation.

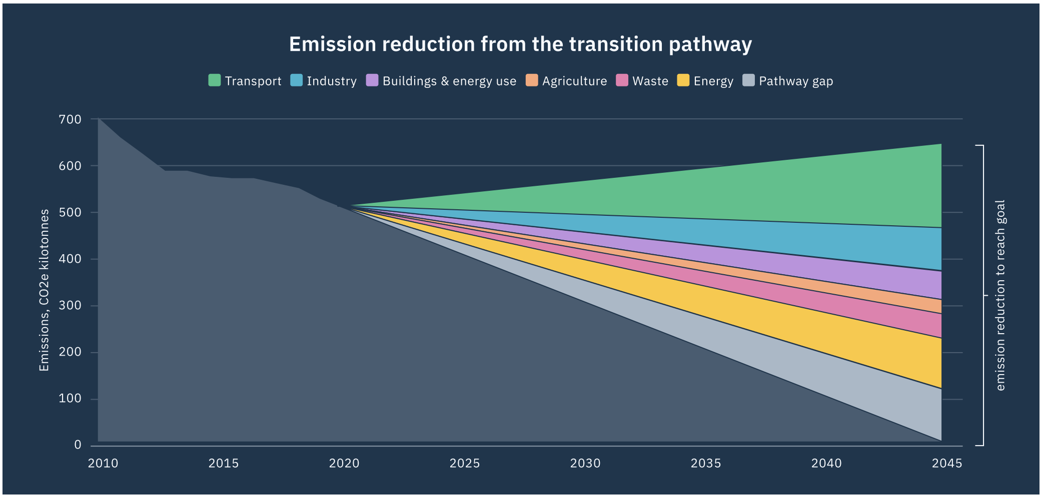


Figure 22. *The Dashboard provides a visual representation of the trajectory.*

The platform, including the Dashboard, can be used on a national level too. Sweden has a net zero goal for 2045, and the Swedish Policy Council is currently using the platform to display Sweden's emissions projections and potential transitions (figure 23), updated biweekly with new policy instruments, commitments, and research. The public visualisation is co-managed by the Swedish Climate Policy Council, Swedish Environmental Protection Agency, and Swedish Energy Agency.

Figure 23. *The Dashboard can be made available to the public.*

SUMMARY

Ultimately, the goal of the ClimateView platform is to make the administration of a transition manageable, transparent, open, and actionable. That transition is supported by confidence built through iterative scenarios, using a methodology that stretches from first principles of physics to behavioural science, and economic opportunities.

The platform is designed to help establish common ground between all stakeholders working towards the transition. This might include those working within the administration, like city climate strategists, politicians, and city departments, as well as those working outside it, like industrial representatives, civil society, and even the citizens themselves.

It serves as a tool for policymakers to navigate their possible futures, and iterate to arrive at the best outcomes for citizens, serving the interests of the public through accountability and transparency.

NOTES

1. Revisions to the text are minimal and are primarily made to reflect changes in terminology since the original version was published.

   - Lever(s) changed to Activity Shift(s)
   - Transition Atlas changed to Periodic Table of Transition Elements
   - ClimateOS changed to ClimateView Platform
   - Five categories of Activity Shifts updated to six with new names
   - Figures updated: 1, 2, 12, 13, 14, 15, 21, 22
   - Glossary added

   The authors would like to acknowledge the contributions of the editor and designers of the original version of this white paper, whose valuable work laid the foundation for this updated publication:

   - Editor & Graphics: Duncan Geere (klimat.studio)
   - Layout & Graphics: Carl Papworth

2. For a deeper understanding of the Transition Elements, see *Standardising Climate Mitigation: The Transition Element Framework*. This white paper introduces the Transition Element Framework (TEF), an open-source project to standardise and organise the climate mitigation options identified by the IPCC into actionable planning information. The TEF addresses the challenges of ambiguous terminology and inconsistent methodologies in climate mitigation by structuring each Mitigation Option into a mutually exclusive, collectively exhaustive (MECE) format, with Activity Shifts as the central elements of emissions reductions. By establishing a detailed ontology and taxonomy, the TEF clarifies definitions and relationships, enhancing the ability to compare, analyse, and implement mitigation strategies across various sectors and regions.

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.

Backcasting - A method to set targets and tempo. Backcasting defines a normative (i.e. desirable) future state, and then determines the pace of change required to reach it, i.e. the tempo.

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 CO2-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.

Gap - The gap between the current status of a city's transition and already-planned interventions, and the desired outcome(s). Identified by asking: will current plans deliver sufficient behaviour change to achieve the objective(s)?

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.

Iteration - In the context of a city transition, this means that a desired future scenario to reach certain objectives is roughly sketched out and refined over time. The route to get there is regularly reassessed, allowing administrations to adapt and respond to new information, emerging technologies, changing political and planetary circumstances, and progress made.

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.

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 CO2 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.

Resources - 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.

Resource flow model - Activity Shifts are interconnected by the resources going into the underlying activities. By tracking the sum of the shifts in resource use for each activity shift, and the tempo of those shifts, it is possible to get a full resource flow model for the set of Transition Elements. This allows stakeholders to compare the effects of different activity shifts, and ensure that their targets are viable by balancing resource needs over time in the city.

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.

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.

Seven step approach - The seven iterative steps of the method – combining the use of the platform and the framework – that support existing processes in civic administrations in the implementation of their scenario, building confidence towards delivering the desired emission reductions and economic outcomes.

Stock - Durable objects used to enable the operations of an activity, e.g. vehicles, buildings, industrial machinery, or infrastructure. Stock can be used repeatedly without being consumed - as opposed to resources. Different types of stock usually have different lifespans..

Target - The total shift required to achieve the desired outcome for an individual activity shift by a specific year set with the backcasting approach.

Tempo - The pace that is needed to reach the targets of individual activity shifts set with the backcasting approach.

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.

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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:

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