3 Understand

This chapter explores the systems dynamics and mental models underlying car dependency. It also assesses the potential of current and planned Irish policies to shift away from car dependency and transition towards sustainable transport systems. The assessment of Irish policies builds on systemic tools (causal loop diagrams, stock and flow analyses, and the leverage points framework) and classifies policies according to their intent (reactive, anticipatory and transformative), and transformative potential (low, medium and high).

The previous chapter illustrated the importance of identifying the goal(s) a properly functioning system should be designed to deliver. It concluded that the transport system's current goal is to increase mobility, which leads to car-dependent systems. These systems perform poorly in terms of well-being, are environmentally unsustainable, and are difficult – if not impossible – to decarbonise in the needed timeframe. In contrast, transport policies and systems guided by sustainable accessibility with low mobility and low emissions can increase well-being. In these systems, most people would use active and shared modes for the bulk of their trips, and distances between people and places would be as short as possible.

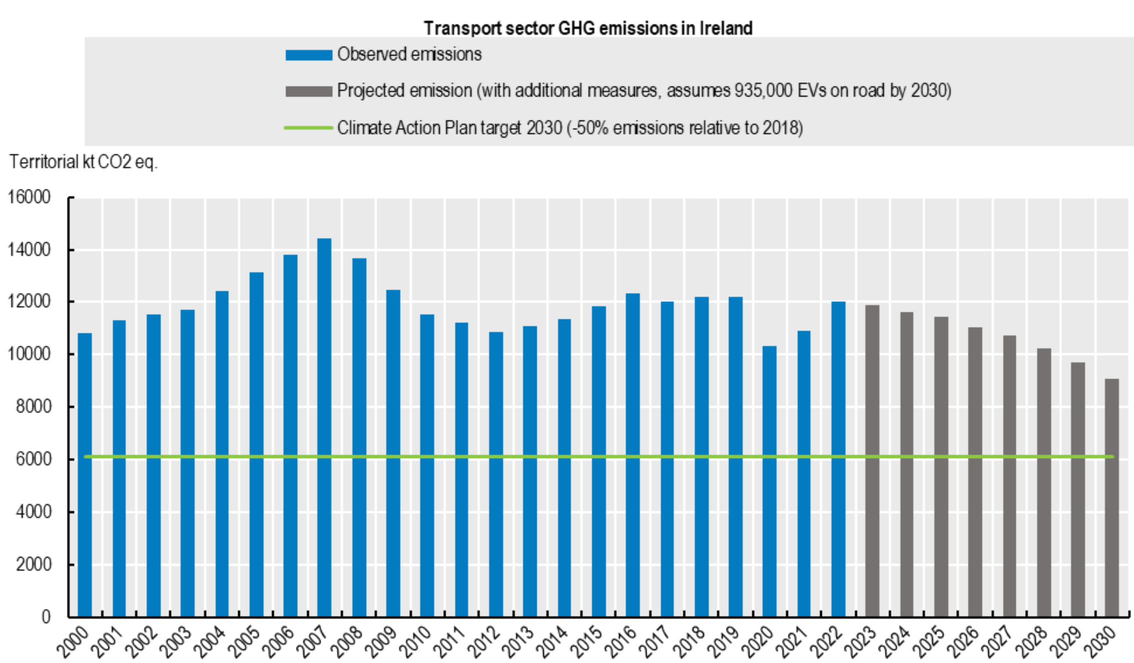
The first section of this chapter analyses the structure of the current transport system in Ireland. It describes three systems dynamics underlying growing car use and high emissions: induced car demand, urban sprawl, and the sustainable modes low-attractiveness trap. The second section assesses to what extent implemented and planned Irish policies have the intent, and the potential, to reverse these dynamics and help Ireland transition towards more sustainable systems.

3.1. What are the key dynamics underlying Ireland's car-dependent system?

The design of Ireland's transport system currently fosters car use and ownership by making the car the most convenient transport mode. Even though this might not have been policy makers' aim, the system leads to high traffic and emissions as well as other negative outcomes such as poor health and safety and unequal access to opportunities.

Passenger cars accounted for 54% of Ireland's road transport emissions in 2020. Partly driven by the growing car use (and increased size of cars) described above, transport GHG emissions remain well above the Climate Action Plan target for 2030 (Department of the Taoiseach Ireland, 2021[1]) (green line in Figure 3.1). The Environmental Protection Agency estimates that a scenario incorporating planned measures, and even including additional measures (such as electrification beyond current targets), would still fall short of the target (Environmental Protection Agency Ireland, 2022[2]).

Figure 3.1. Transport sector GHG emissions in Ireland



Source: Adapted from (Environmental Protection Agency Ireland, 2022[2]), www.epa.ie/our-services/monitoring--assessment/climate-change/ghg/transport/.

This report finds that the increased traffic volumes and car use observed in Ireland are not inevitable consequences of “progress”, which transport and climate policies need to accommodate. They are the result of unsustainable system dynamics, which can be redesigned.

The choice to drive a car is not solely the result of individual preferences (i.e. exogenous to the system), as is often argued. It is determined largely by transport and urban systems organised around car driving, and in particular by the three unsustainable dynamics of “induced car demand”, “urban sprawl” and the “sustainable modes low-attractiveness trap”. These three dynamics produce growing car use, high emissions, and negative impacts on well-being.

The following subsections illustrate each of the three unsustainable dynamics via causal loop diagrams (CLDs). CLDs shed light on the system’s structure and feedback loops underlying the patterns of behaviours observed. See Box 3.1 for more information (Meadows, 2008[3]).

Box 3.1. An introduction to Causal Loop Diagrams (CLDs)

This report is based on one of the key insights from systems science: the idea that the structure of a system causes the patterns of behaviour observed (Sterman, 2000[4]; Meadows, 2008[3]; Systems Innovation, 2020[5]). By shedding light on the system's structure, CLDs can help policymakers identify where to intervene in the system to address the root causes of the problems that their policies are trying to solve.

CLDs are used throughout the report to illustrate the structure underlying car dependency and the negative outcomes related to it (e.g. high emission levels, unequal access to opportunities). CLDs may seem intimidating at a first glance, but they are in reality easy to understand.

A causal loop diagram (CLD) is a map representing a system's structure by its causal relationships. A CLD includes the following elements:

- The individual elements of the system, represented by text variables.
- Causal relationships between the variables, represented by links or arrows. When taken individually, and depending on the type of causal relationship, variables will vary in the same or in the opposite direction. In this report, a pink arrow indicates a causal relationship in which variables vary in the same direction, e.g. as the attractiveness of driving cars increases/decreases, so does the number of people that choose to drive cars. A blue arrow represents a causal relationship in which variables vary in the opposite direction: as congestion increases, the attractiveness of driving a car decreases.
- Delays, represented by two lines crossing the arrows. A delay indicates that it will take time for changes in one variable to cause changes in the other.
- Feedback loop labels, indicating whether a loop is reinforcing (R) or balancing (B).

Feedback loops are non-linear causal relationships. In linear causal relationships, a variable (the cause) affects a second variable (the effect), and the causal chain stops there. In non-linear causal relationships, often referred to as feedback loops, a variable affects a second variable, which in turn affects the first variable again: the variables feed into each other, leading to circular – rather than linear – causal chains (Meadows, 2008[3]).

Feedback loops can be reinforcing or balancing. In reinforcing feedback loops, the effect of the first variable alters the second, which feeds back to affect the first variable again, in the same direction (e.g. more eggs, more chickens, more eggs). In balancing feedback loops, variables affect each other in opposite directions (e.g. more foxes, less rabbits, less foxes). Reinforcing feedback loops lead to acceleration: when observed over time, systems dominated by reinforcing feedback loops produce exponential curves (positive or negative)[1]. Systems dominated by balancing feedback loops seek an equilibrium – that may be above or below the current state of the system – which is generally reached by exponential decay. More complex behaviours, e.g. oscillations, s-shaped growth and overshoots, are produced by the interactions between several feedback loops and time delays.

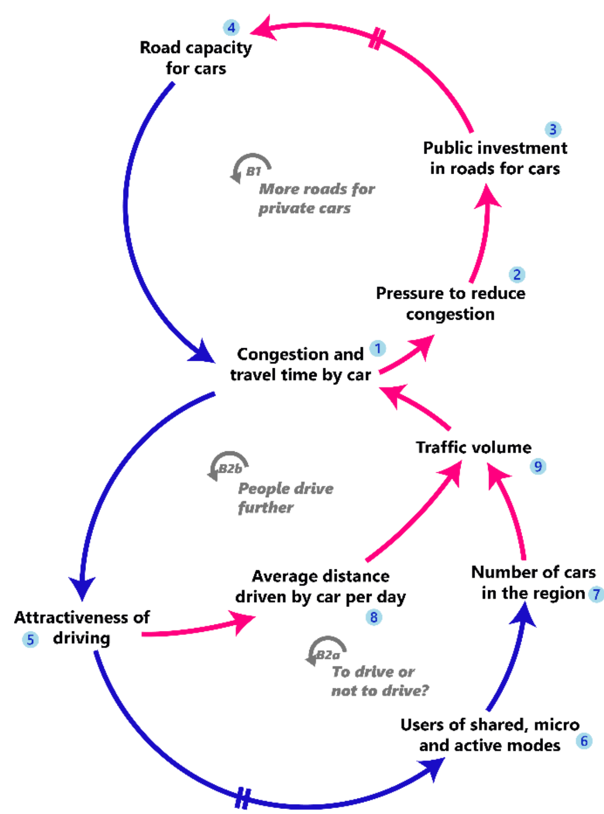
1 Note that systems dominated by positive feedback cannot last over long periods of time (i.e. they are necessarily unsustainable) as all systems are embedded within an environment which will, at a certain point, place limits on exponential growth (Systems Innovation, 2021[6]).

3.1.1. Induced car demand

Induced car demand refers to the way in which investment in road expansion intended to reduce congestion has the opposite effect (WSP and RAND Europe, 2018[7]).[1] Figure 3.2 illustrates the dynamic of induced car demand. The more people choose to drive, the more congestion and travel time by car (1) increases. As congestion and travel time by car (1) increase, so does the pressure to reduce congestion (2) (no one likes to be stuck in traffic jams). The conventional policy response to this pressure has been to increase public investment in roads for cars (3). For example, in the late 20th century and beginning of the 21st, the road network in Ireland was expanded and upgraded by large public investment (Department of Transport Ireland, 2020[8]). Public investment in roads for cars (3) increases road capacity for cars (4), which, all else being equal, reduces congestion and travel time by car (1)[2].

However, as congestion and travel time by car are reduced (1), the attractiveness of driving (5) compared to other modes increases. This results in fewer users of shared, micro and active modes (6), a higher number of cars in the region (7), and longer average distance driven by car per day (8); all of which increases traffic volume (9), congestion and travel time by car (1). Note that this is the opposite effect that increased public investment in road for cars (3) intended to obtain. For example, Ireland's motorway M50 has been widened and upgraded at various times to accommodate increasing travel demand. Despite the upgrades, the motorway is constantly congested (Transport Infrastructure Ireland, 2017[9]).

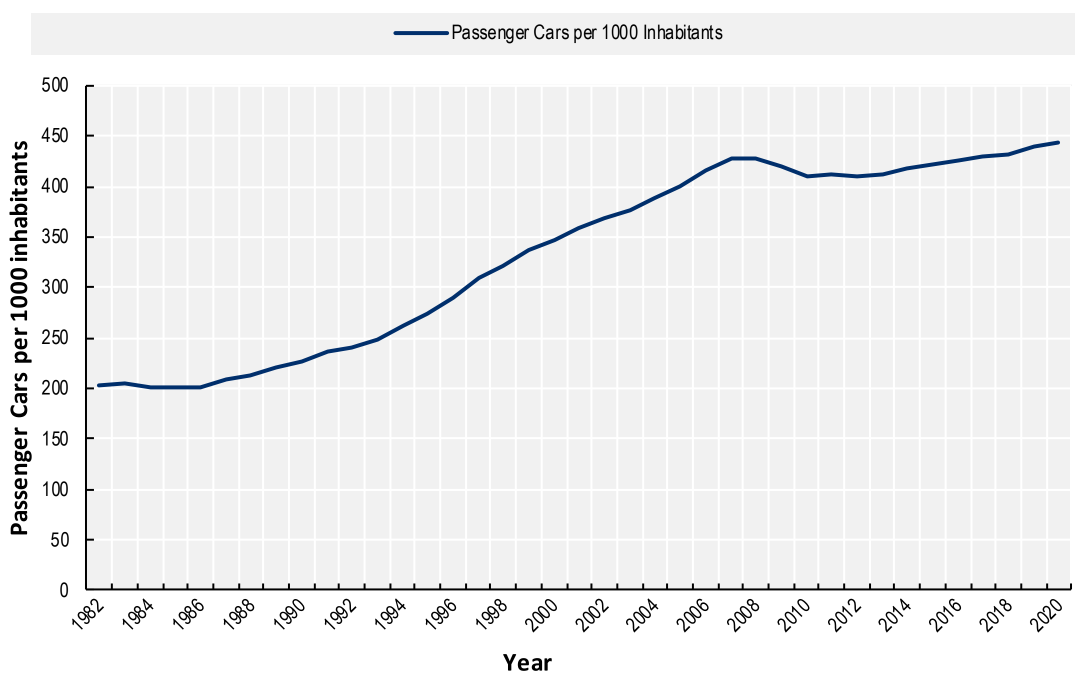
Figure 3.2. Systems dynamics underlying induced car demand



Note: The coloured arrows show the relationship between variables. A pink arrow between variables means that they vary in the same direction: an increase in a variable leads to an increase in the variable it points at; a decrease in a variable leads to a decrease in the variable it points at. A blue arrow means that variables vary in the opposite direction: an increase in a variable leads to a decrease in the variable it points at; a decrease in a variable leads to an increase in the variable it points at. Each loop label (e.g. B1) denotes a feedback loop. A feedback loop is either reinforcing (R), or balancing (B). See Box 3.1 and section 3.1 for more information on how to read causal loop diagrams.

While studies assessing the effect of induced car demand in Ireland could not be found during the literature review carried out for this report, data suggests that public investment in roads for cars has historically been favoured over other types of infrastructure in the country and that car ownership has grown over the same period. Between 2006 and 2019, the financial resources allocated to roads for cars more than doubled the resources allocated to infrastructure for public transport (OECD, 2021[10]) (see Section 3.2.2 for more). Between 1982 and 2020, the number of cars per 1000 inhabitants in Ireland increased from 203 to 444 passenger automobiles (Figure 3.3) and Transport Infrastructure Ireland (2019[11]) estimates that the total fleet of private vehicles would continue to rise 30% by 2030 (compared to 2016) (accessed from (Caulfield, Carroll and Ahern, 2020[12])). This trend is not unique to Ireland. For example, new passenger cars registered in the EU grew by almost 10% between 2015 and 2020 (Eurostat, 2022[13]).

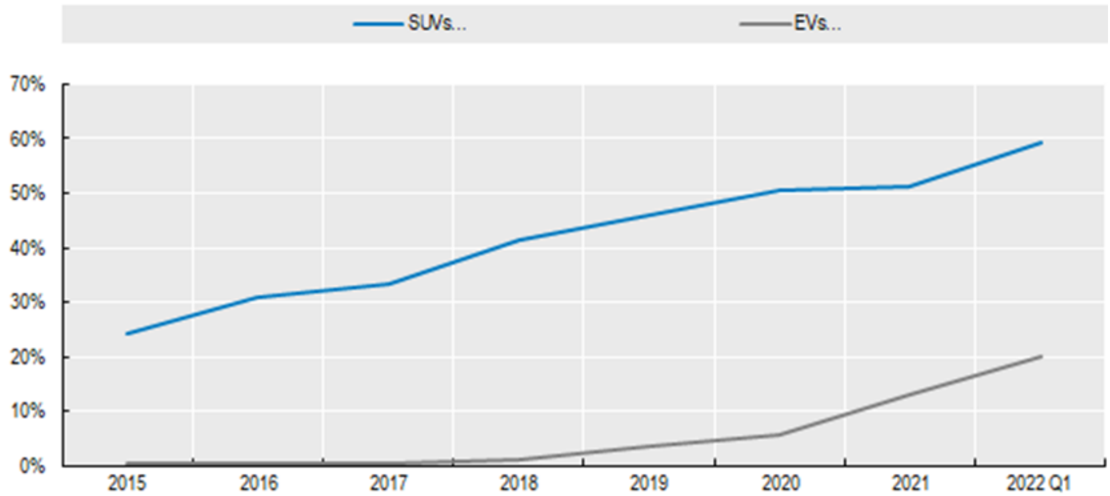
Figure 3.3. Passenger Cars per 1000 Inhabitants in Ireland



Source: Adapted from (CSO Ireland, 2022[14]), https://data.cso.ie/. Population figures (Eurostat, 2022[15]), https://ec.europa.eu/eurostat/web/population-demography/demography-population-stock-balance/database

A worrying trend towards larger cars (which require more energy) is also observed: sports utility vehicles (SUVs) accounted for half of new car registrations in Ireland in 2021, up from 24% in 2015 (Society of the Irish Motor Industry, 2022[16]).

Figure 3.4. Passenger SUV and EV registrations in Ireland (share of total registrations)



Note: The figures are not mutually exclusive (SUVs can be EVs) and refer to registration of new cars.
Source: Adapted from (Society of the Irish Motor Industry, 2022[16]), https://www.simi.ie/en/motorstats

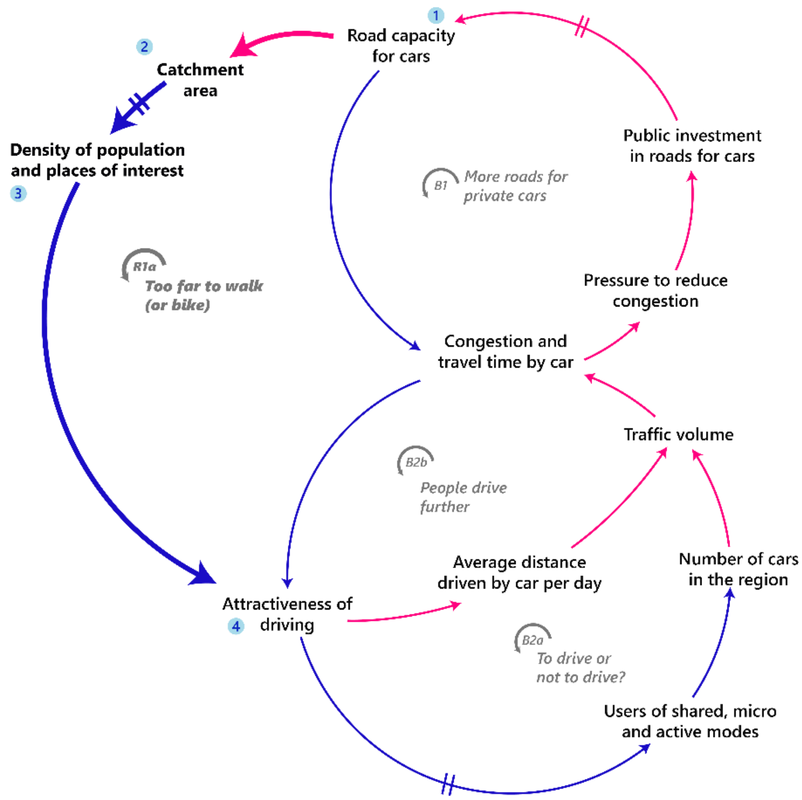
3.1.2. Urban sprawl

Urban sprawl occurs when people move away from the inner areas of a city or town. While the term is defined in multiple ways in literature, sprawl is often characterised as low-density development that is “discontinuous, strongly scattered and decentralised” (OECD, 2018[17]).

As road capacity for cars (1, in Figure 3.5) increases, so does the catchment area (2), that is, the region from which a city, service, or institution draws residents to use its services (Cambridge Dictionary, 2022[18]). Higher road capacity for cars (1) increases the catchment area (2) by increasing the number of places from which the inner area can be accessed within a reasonable time budget, such as 30 minutes by car.

As the catchment area (2) grows, previously inaccessible sites can be populated with suburbs. With more suburban development, often following a scattered and single-use development pattern, the density of the population and places of interest (3) declines. When densities of both kind decline, the attractiveness of driving (4) grows because distances increase (R1a in Figure 3.5).

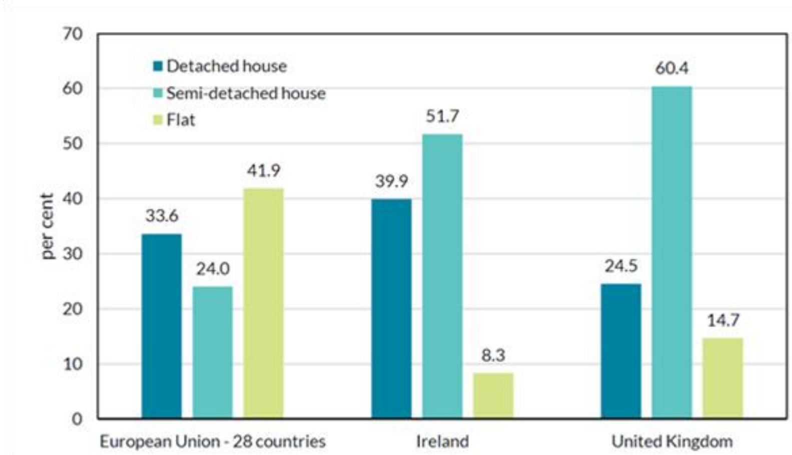
Figure 3.5. System dynamics underlying urban sprawl



Note: This diagram builds on Figure 3.2. The coloured arrows show the relationship between variables. A pink arrow between variables means that they vary in the same direction: an increase in a variable leads to an increase in the variable it points at; a decrease in a variable leads to a decrease in the variable it points at. A blue arrow means that variables vary in the opposite direction: an increase in a variable leads to a decrease in the variable it points at; a decrease in a variable leads to an increase in the variable it points at. Each loop label (e.g. B1) denotes a feedback loop. A feedback loop is either reinforcing (R), or balancing (B). See Box 3.1 and section 3.1 for more information on how to read causal loop diagrams.

The construction of buildings and road infrastructure during periods of rapid economic growth, combined with a lack of spatial planning and poor public transport development, has contributed to Ireland's dispersed land use (Ahrens and Lyons, 2019[19]). Motorway access facilitates the development of new low-density areas (Ahrens and Lyons, 2019[19]), leading to developments in more scattered and remote locations compared to other European countries (Ahrens and Lyons, 2019[19]). For example, during 1991-2016, populations in outer urban and suburban areas, poorly connected by public transport (and thus car-dependent), grew while inner-city populations declined (Carroll and O'Sullivan, 2020[20]). As a result, Ireland's settlement patterns are highly and increasingly dispersed (Ahrens and Lyons, 2019[19]). Over 90% of the population – above the EU average – lives in detached or semi-detached houses, which further contributes to low-density living (Figure 3.6). This geographical situation is particularly challenging, as many people are currently isolated and do not have healthcare, education, shopping, employment, leisure, entertainment or culture accessible to them, and are thus extremely car dependent. Chapter 4 discusses policy recommendations and provides some insights on how these could be adapted to different contexts.

Figure 3.6. Population distribution by type of housing



Source: (Central Bank of Ireland, 2019[21]), based on Eurostat data

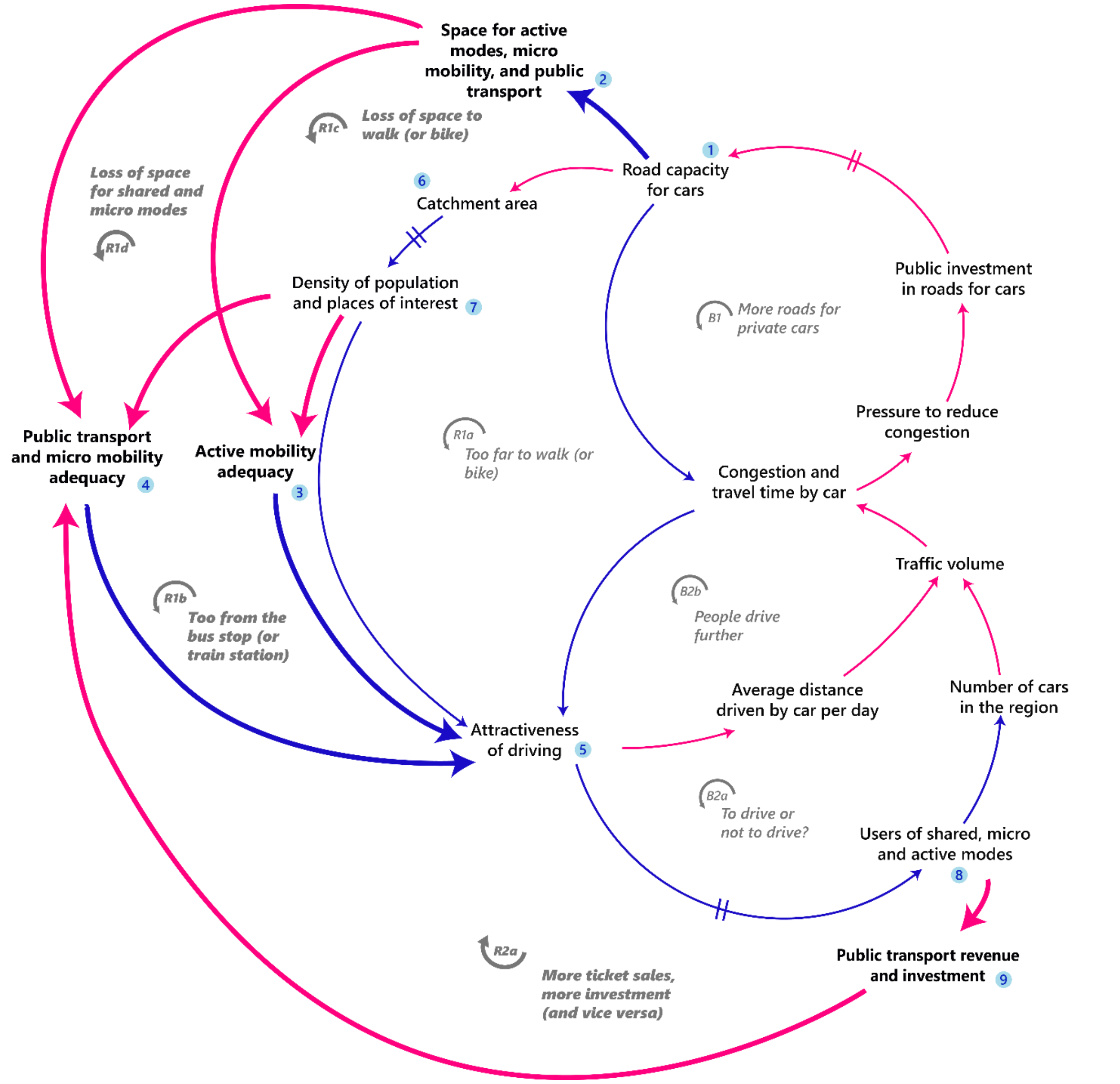
Both these dynamics (induced car demand and urban sprawl) erode the attractiveness of sustainable modes, as described in the next section.

3.1.3. Sustainable modes low-attractiveness trap

Prioritising public investment in road for cars reduces the total investment going to sustainable modes, as these investments compete with each other within countries' transport budgets (not shown in Figure 3.7). The prioritisation of investments to roads for cars has led to high road capacity for cars (1 in Figure 3.7), which has reduced the availability of safe and dedicated space for active modes, micro mobility and public transport (2), reducing their adequacy (3 and 4) which increases the attractiveness of driving (5).

As increasing road capacity for cars (1) expands the catchment area (6) and reduces the density of population and places of interest (7), the density reduction further jeopardises active mobility, public transport and micro mobility adequacy (3 and 4). The frequency of service decreases and fewer places are conveniently accessible by bus and train. The number of places of interest reachable by foot or bicycle also decrease as the catchment area expands; further contributing to the attractiveness (and necessity) of driving (5). For public transport and micro mobility, a decline in the number of users (8) also reduces public transport revenue and investment (9), which may further reduce the services' adequacy (4) and increase the attractiveness of driving (5).

Figure 3.7. System dynamics underlying the sustainable modes low-attractiveness trap



Note: This diagram builds on Figure 3.5. The coloured arrows show the relationship between variables. A pink arrow between variables means that they vary in the same direction: an increase in a variable leads to an increase in the variable it points at; a decrease in a variable leads to a decrease in the variable it points at. A blue arrow means that variables vary in the opposite direction: an increase in a variable leads to a decrease in the variable it points at; a decrease in a variable leads to an increase in the variable it points at. Each loop label (e.g. B1) denotes a feedback loop. A feedback loop is either reinforcing (R), or balancing (B). See Box 3.1 and section 3.1 for more information on how to read causal loop diagrams.

Decades of investment prioritisation towards road infrastructure for cars without ensuring dedicated space for public transport and active modes has greatly slowed the development of these modes in Ireland and increased perceptions of their unsuitability, particularly in low-density areas. As shown in Figure 3.21 in section 3.2.2, from 2006 to 2019 Ireland spent twice as much on roads for cars as on sustainable mobility. Meanwhile, the infrastructure for sustainable modes remains poor. In Dublin, for example, narrow, poor-quality footways create a barrier to pedestrian movement, particularly for people using mobility aids (National Transport Authority Ireland, 2021[22]), and only 16% of main commuting routes have segregated cycle lanes (compared to, for example, 77% in Copenhagen) (Conway et al., 2019[23]). As a result, public transport, walking and cycling represent a small share of trips in Ireland on average: 7, 14 and 2%, respectively (CSO, 2019[24]). Decreasing densities and increasing distances have further reinforced the low-attractiveness of these modes and further hindered the development of adequate infrastructure, reflected by smaller shares of these trips in thinly populated areas of Ireland (2, 8 and 1% respectively), compared to densely populated ones (12, 19 and 3% respectively) (CSO, 2019[24]).

The next section assesses the potential of implemented and planned policies in Ireland to reverse the dynamics of induced car demand, urban sprawl and the sustainable modes low-attractiveness trap.

3.2. Are Irish policies transformative?

The previous section outlined the three dynamics leading to growing car use, unsustainable levels of emissions, and other negative outcomes (e.g. air pollution, limited accessibility, etc.) in Ireland. This section assesses the intent and transformative potential of implemented and planned policies, asking whether they can reverse these dynamics and lead to a system designed to deliver sustainable accessibility. The framework provides a practical way to discuss previously analysed policy options in the light of a systemic approach. Where relevant, findings from existing work are cited[3].

Section 3.2.1 describes the framework guiding the assessment. Section 3.2.2 presents the assessment results.

3.2.1. A framework to categorise policies according to their intent and transformative potential

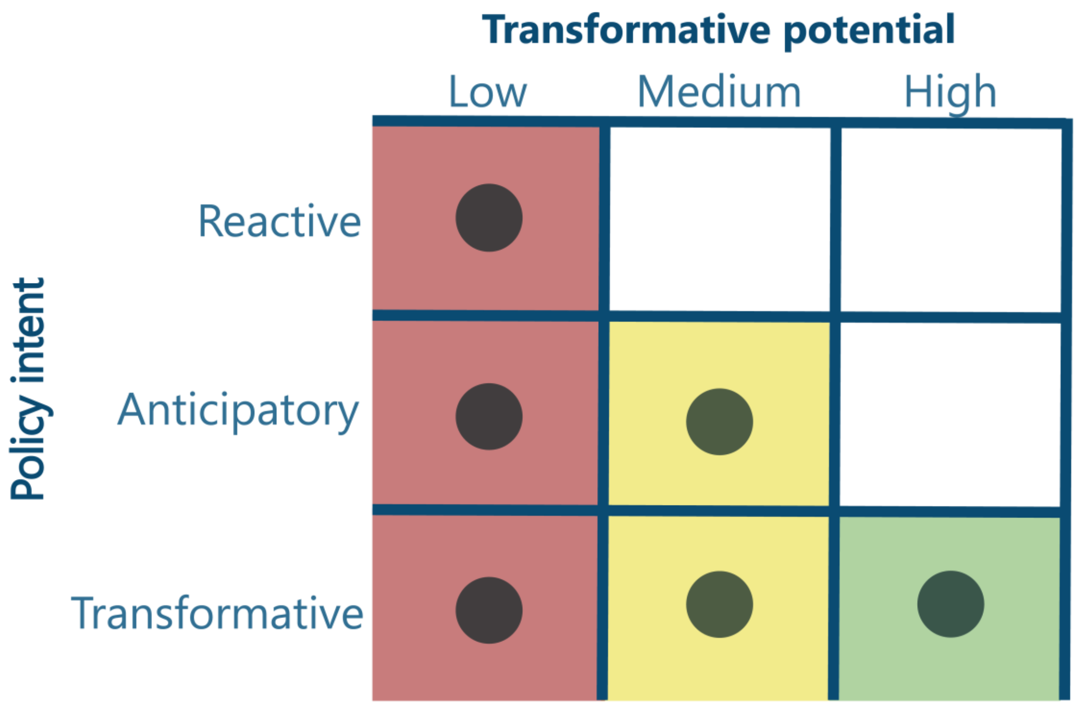
This section describes the framework used in this report to assess policies' intent and transformative potential. The framework is part of the "Understand" step of the "Systems Innovation for Net Zero" process described in the Overview chapter, and builds on a key insight of systems thinking – that the structure of a system (e.g. feedback loops, delays) causes the patterns of behaviour observed (Sterman, 2000[4]; Meadows, 2008[3]; Systems Innovation, 2020[5]).

The assessment classifies policies according to their intent and their transformative potential in current systems. Policies' intent is characterised as reactive, anticipatory, or transformative. The transformative potential is linked to the actual impact the policy has on current systems, which is characterised as low, medium, or high.

Figure 3.8 illustrates the two dimensions used in the assessment. As explained in more detail below, reactive and anticipatory policies have low to medium transformative potential since they do not aim to address root causes. The transformative potential of policies with a transformative intent can be low, medium, or high depending on the state of the system the policy is trying to influence and the policy's scale or level of ambition.

Note that while the framework assesses individual policy intent and transformative potential, no single policy can transform a complex system. An assessment of each one, however, can help policy makers identify policies with high transformative power and design policy packages that prioritise them. Furthermore, if the policy package is designed with a transformative intent, the power of policies with low or medium transformative potential when implemented in isolation may increase (e.g. carbon prices: see 3.2.2 and Table 4.1 in Chapter 4).

Figure 3.8. The transformative potential of reactive, anticipatory and transformative policies



The framework combines a number of systemic tools for identifying policies' intent and transformative potential. The rest of this section describes them.

Assessing policies' intent

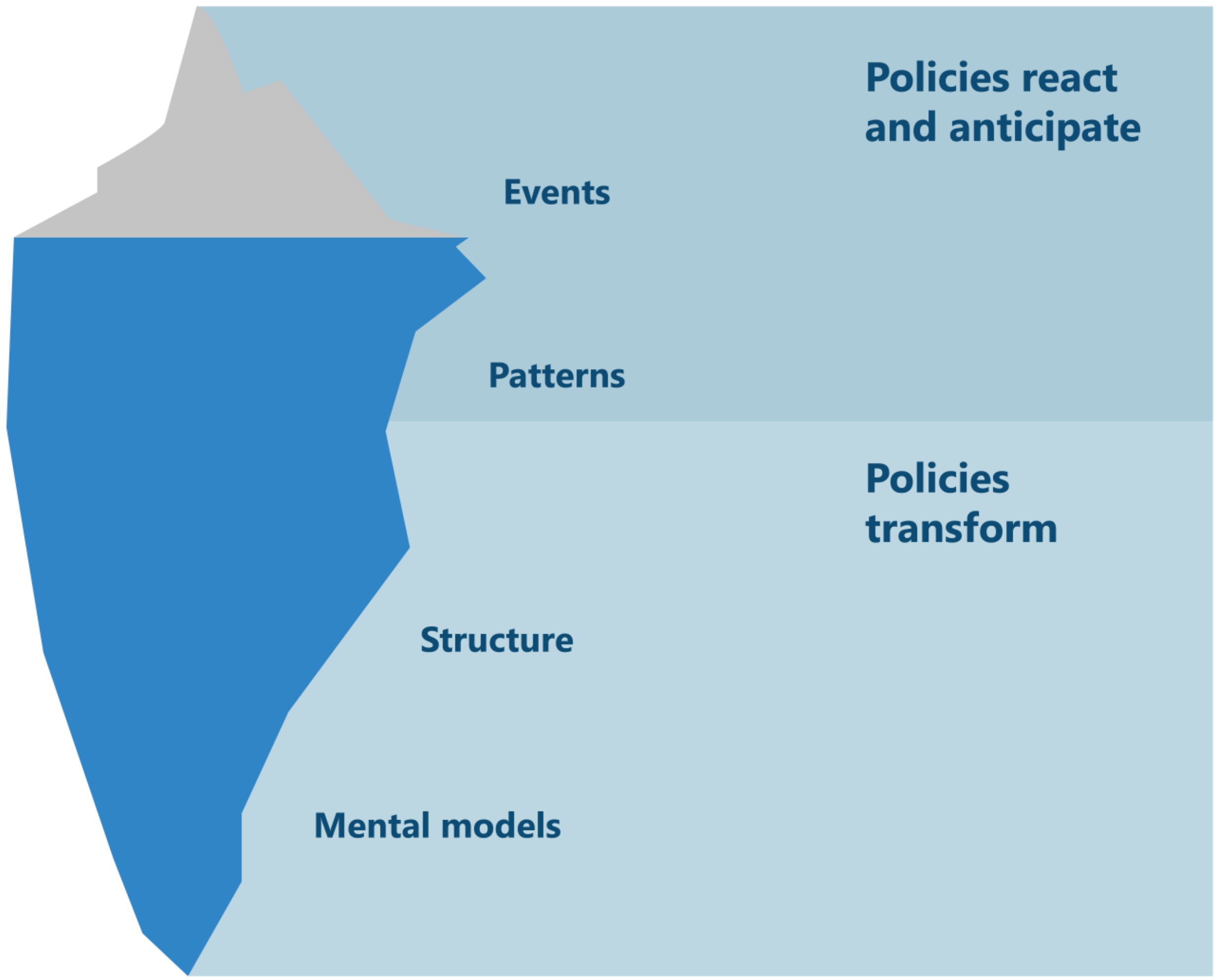
The iceberg model, introduced in the Overview chapter, is used to identify the policy intent. The notion of "basins of attraction", described in Box 3.2, and the analysis of mental models discussed in Chapter 2, complement the iceberg analogy.

A focus on what is visible and immediate (the "tip of the iceberg") has led to decades of policies and actions that react to events or anticipate patterns. Reactive policies and actions minimise the harm of observed events and do not address their root causes. For example, on days of peak air pollution in Paris, cars with certain registration numbers are not allowed to circulate. While this is a necessary reaction, the policy does not decrease the likelihood or frequency of pollution peaks in the future. Opening parks at night during heat waves is another example of a reactive action (non-transport-related).

Anticipatory policies aim to reduce the harms of predicted trends; they aim to prevent the harms of expected events based on historical information. For example, a trend towards more frequent pollution peaks coupled with evidence of the effect of air pollution on children's health (e.g. asthma) may lead city officials to install air purifiers in schools so as to reduce children's exposure to polluted air. This action anticipates negative impacts on children's health and "gets the city ready" to reduce them. Like reactive policies, anticipatory policies do not decrease the likelihood that future patterns will be similar to those in the past since they do not address root causes.

While reacting to events and anticipating patterns can be fundamental, policy packages mainly focused on reacting or anticipating have a small chance to change existing patterns of behaviour. As the examples above show, this is because the structure of the system, which lies at the source of such patterns, remains intact (Sterman, 2000[4]; Meadows, 2008[3]; Systems Innovation, 2020[5]).

Figure 3.9. The iceberg model for categorising policies by their intent



To influence current transport patterns of behavior (e.g. people choosing cars over sustainable transport modes for the bulk of their trips), and meet climate mitigation goals, the IPCC calls for transformative changes in the transport sector (IPCC, 2022[25]). Transformative policies aim to shift away from unsustainable systems dynamics and mental models towards systems that encourage patterns of behaviour in line with the envisioned results. Transformative policies can “dissolve” problems by dealing with their root causes. For example, road space reallocation (discussed in section 3.2.2) can dissolve the problem of air pollution from transport by contributing to creating a virtuous system structure in which public transport and active modes become the most attractive mode, safety-, time- and cost-wise, for the bulk of trips, and thus those most often chosen.

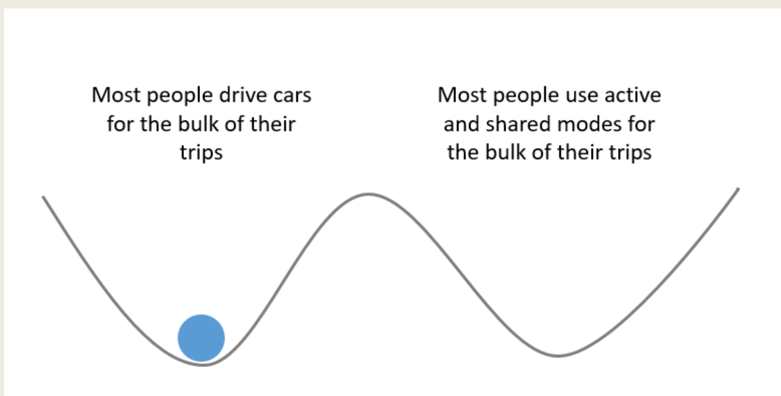
Identifying the intent underlying policy design is a necessary but insufficient step towards understanding policies’ transformative potential. This potential is highly dependent on the level of physical (e.g. road infrastructure) and non-physical (e.g. mindsets) lock-in of the system the policy is trying to influence. For example, in car-dependent systems, where most public space and infrastructure is locked in for car use, road pricing can slow down the dynamic of induced car demand by increasing the cost of driving. It is however unlikely to trigger behavioural change at large scale (e.g. most people choosing sustainable modes for the bulk of their trips), as this would require not only slowing down but reversing induced car demand. In car-dependent systems, cars still remain the fastest mode of transport, and those that most people choose for the bulk of their trips. The policy may contain and even stabilise traffic volume, but the system design (based on the goal of mobility and high speed) is still pushing towards high car use (see further discussion in section 3.2.2).

Box 3.2. Flipping the basin of attraction for large-scale behavioural change

The transition that transformative policies are able to trigger can be illustrated by the notion of "basins of attraction", which complements the iceberg model.[1]

The left-hand side of Figure 3.10 represents the current state or basin of attraction in Ireland: most people drive cars for the bulk of their trips, since cars are the most attractive transport mode across the country. The right-hand side of the figure represents the desired system state[2]: most people use active and shared modes (the pattern of behaviour) for the bulk of their trips, which evidence suggests can lead to high well-being and low emissions (see Chapter 2).

Figure 3.10. Current and potential transport choices in Ireland



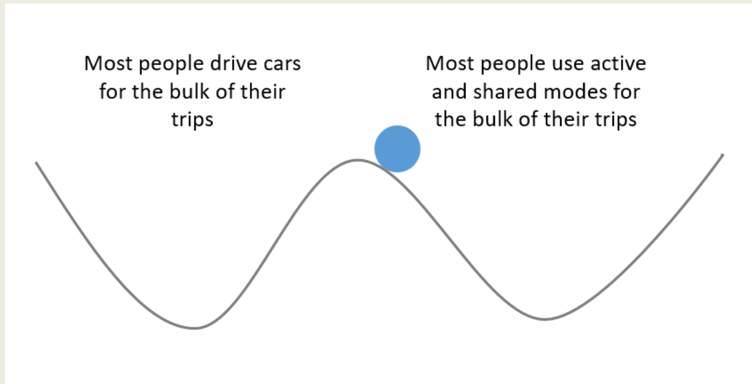
The difficulty of "flipping" the basin of attraction depends on the depth of the basin on the left, which is intrinsically related to the physical infrastructure in the system. In the case of Ireland, the transport system is locked into a high car use equilibrium (left-hand side of Figure 3.10) since most infrastructure is car-oriented. From a historical perspective, the basin on the left is deep, at least partly because of decades of investment in car-purposed road infrastructure, car-centric communication efforts and a lack of investment in public and active mode infrastructure.

The notion of basins of attraction can be linked to the policy categorisation described in this section:

- Reactive and anticipatory policies do not move the ball: by assuming that cars are the system's inevitable attractor, they aim to minimise the negative consequences of growing car use, for example by encouraging the purchase of fuel-efficient or electric vehicles instead of combustion vehicles.
- Transformative policies with low to medium transformative potential aim to trigger behavioural change in the direction of sustainable modes, but do not manage to flip the basin of attraction. For example, carbon prices push the ball towards the right by increasing the cost of driving. They are, however, insufficient to push the ball "up the hill" in car-dependent systems, since other factors such as safety, time savings and access lead to cars' remaining the system's attractor.
- Policies with high transformative potential can move the ball from the basin on the left to the top of the hill (Figure 3.11). When implemented on the right scale, they have the potential to "flip" the

basin of attraction by shifting away from unsustainable systems dynamics and mental models, so that the system deliberately encourages patterns of behaviour in line with the envisioned results.[3]

Figure 3.11. The effect of transformative policies



The notion of basins of attraction is linked to several characteristics of complex systems. First, complex systems can have more than one basin of attraction[4] (Systems Innovation, 2022[26]), and thus different patterns of behaviour can emerge. Second, in non-linear systems[5] change can be rapid once the right conditions are introduced. Note that transformative efforts do not need to "push" the ball down into the second basin: these efforts set the conditions for the ball to fall on its own as the system design reaches a new equilibrium. Third, the deeper the basin of attraction, the greater the need to prioritise transformative policies with high transformative potential ("deep under the surface" in the iceberg analogy). In locked-in systems like the Irish transport system, policies with low to medium transformative power are insufficient to trigger behavioural change at the pace and scale needed; the behaviour patterns emerging from car-dependent systems prevail and often offset any benefits of change (see, for example, (Lamb et al., 2021[27]) for more on this).

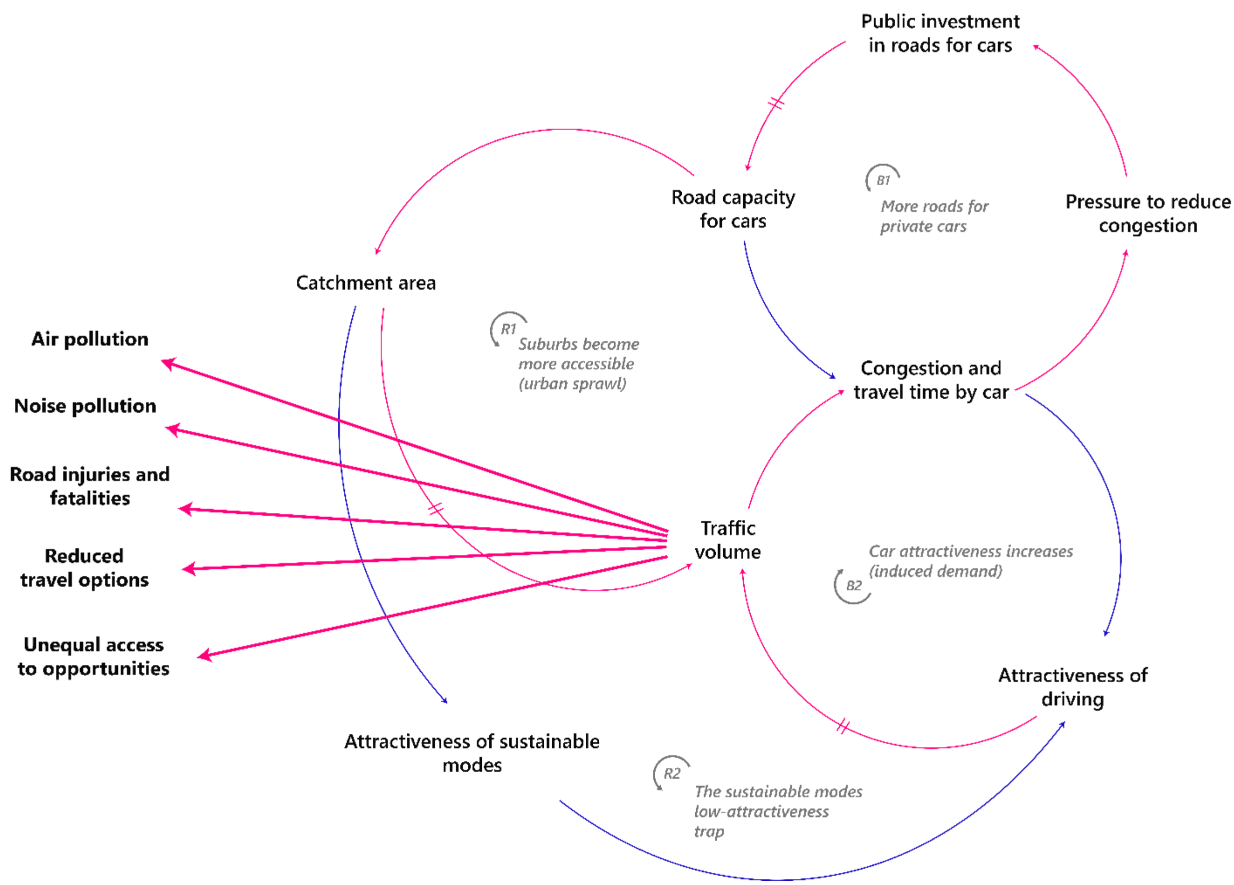
1 Metaphors, while necessary, are inherently limited. Linguists and cognitive scientists Lakoff and Johnson explain that "[b]ecause so many of the concepts that are important to us are either abstract or not clearly delineated in our experience (the emotions, ideas, time, etc.), we need to grasp them by means of other concepts that we understand in clearer terms (spatial orientations, objects, etc.)". However, "[t]he very systematicity that allows us to comprehend one aspect of a concept in terms of another … will necessarily hide other aspects of a concept" (Lakoff and Johnson, 2008[28]), accessed from (Te Brömmelstroet, 2020[29]).
2 Note that this second state becomes possible and desirable only after the system's goal has been redefined away from mobility towards sustainable accessibility, i.e. only once high mobility is no longer associated with high well-being. See Chapter 2 for more on this.
3 As noted before, no policy is able on its own to transform complex systems. Transformative policies need to be embedded in policy packages.
4 Two iceberg models, one for the current and one for the emergent system, would be another way of visualising this.
5 "Linearity implies that the size of the change is correlated with the magnitude of the input to the system. A small input will have a small effect and a large input will have a large effect in a linear system". In complex, non-linear, systems, the "size of the outcome may not be correlated to the size of the input": a small action may lead to big changes and vice versa (Zimmerman, Lindberg and Plsek, 2009[30]).

Assessing policies' transformative potential

Three systemic tools are used to identify policies' transformative potential: causal loop diagrams, stock and flow analysis, and Meadows leverage points framework, to be explained below. These tools trigger questions such as whether a policy strengthens or weakens feedback loops, can change a loop's dominance, or lead to the creation of new loops. The rest of the section describes these tools in detail.

To identify a policy's transformative potential—that is to say, the actual effect a policy can have on current systems—understanding the system's feedback loop structure is fundamental. Causal loop diagrams (CLDs), such as Figure 3.12 shed light on these structures. They can be seen as a deep dive into the iceberg model's "structure" level, enabling the analyst to better understand the interconnections or causal relationships that produce the results at the tip of the iceberg. Figure 3.12 summarises the dynamics explained in section 3.1 and the negative outcomes associated with them. An expanded version, tailored to the Irish transport system, is presented in Annex D.

Figure 3.12. System dynamics underlying car dependency and its effects



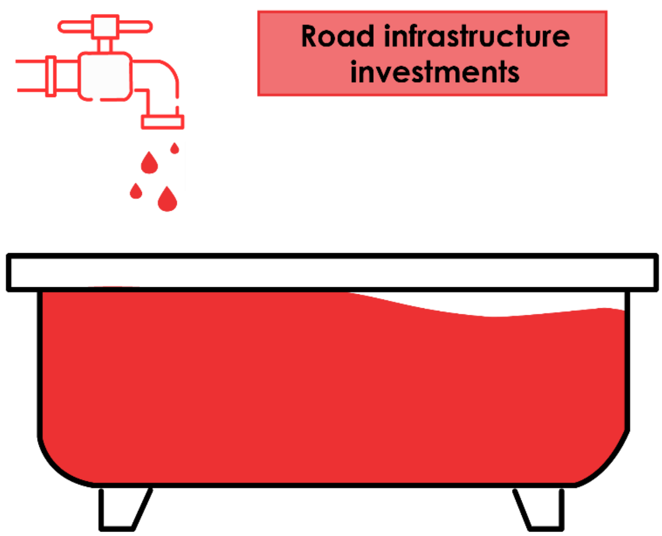
Note 1: Induced car demand occurs when public investment in roads for car use causes more, rather than less, traffic congestion. Urban sprawl is the simultaneous dynamic by which people move away from city centres while still commuting to those centres. Both induced car demand and urban sprawl exacerbate the sustainable modes low-attractiveness trap, the third vicious cycle at the source of increased car use and emissions. As more and more people are induced to drive cars, and policy makers respond by increasing the road capacity for cars, traffic volume of motorised vehicles and the space and funding allocated to them increase, while those allocated to public transport and active modes decrease. As more and more people move to peripheries, daily distances travelled increase and a good transport service becomes difficult and expensive. Active modes are also no longer feasible or competitive options. Unsurprisingly, in this type of system the attractiveness of sustainable modes is low.
Note 2: The coloured arrows show the relationship between variables. A pink arrow between variables means that they vary in the same direction: an increase in a variable leads to an increase in the variable it points at; a decrease in a variable leads to a decrease in the variable it points at. A blue arrow means that variables vary in the opposite direction: an increase in a variable leads to a decrease in the variable it points at; a decrease in a variable leads to an increase in the variable it points at. Each loop label (e.g. B1) denotes a feedback loop. A feedback loop is either reinforcing (R), or balancing (B). See Box 3.1 and section 3.1 for more information on how to read causal loop diagrams.

Source: (OECD, 2021[10]), www.oecd.org/environment/cc/policy-highlights-transport-strategies-for-net-zero-systems-by-design.pdf.

Stock and flow analyses complement CLDs in the study of policies' transformative potential by helping policy makers understand the system's physical lock-in.[4] Stock and flow analyses shed light on the magnitude of the stocks – one indication of a system's physical lock-in – and the magnitude and speed of change those variations in flows may trigger in existing stocks. Stocks and flows are the elements of a system; stocks (e.g. vehicle fleet, public transport infrastructure) change over time due to inflows and outflows, and are the "system memory". The systems that policies seek to influence have been shaped by decades of decisions made by the multiple stakeholders who act within the system.

Stocks and flows are often analysed using a bathtub analogy: Figure 3.13 applies this to transport infrastructure in Ireland. Investment in transport infrastructure creates flows, like water from a tap. Here the road infrastructure tap pours red water into a bathtub and the sustainable transport infrastructure tap pours blue water into the same bathtub. Over the years, the accumulation of investment becomes the country's transport infrastructure, illustrated by the water in the bathtub.

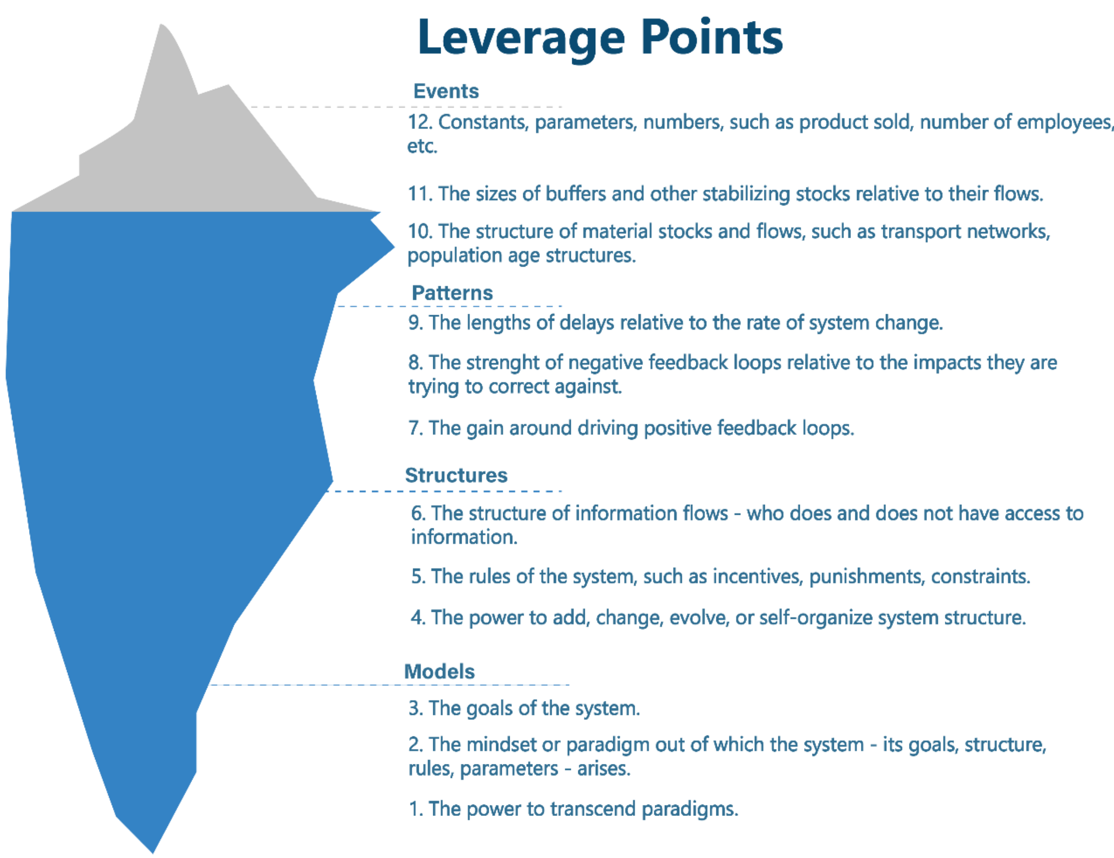
Figure 3.13. Stocks and flows: an illustration



Understanding the magnitude of stocks and flows can shed light on policies' transformative potential in a number of ways. First, potential mismatches between the level of ambition or policy stringency and the magnitude of the stocks the policy is trying to influence can be identified. For example, while Irish efforts to improve public transport infrastructure have a transformative intent, their transformative power is limited in the current system. The transport system is characterised by decades of investment leading to an accumulation of the stock of car-purposed infrastructure. As a result, the system's lock-in highly favours cars and current efforts to reallocate budgets towards public transport (2:1 ratio, see section on budget reallocation), while substantial, are insufficient to "flip" the basin of attraction (see Box 3.2) and trigger behavioural change at the required pace[5]; alternative modes would remain less attractive than cars for decades at the current pace of change. Note that the same efforts made decades ago, when the gap between car and public transport infrastructure was smaller, could have had a higher transformative power, as the case of the Netherlands illustrates (see section 3.2.2.). Second, stock and flow analyses can remind policy makers that policy action is not limited to opening and closing taps (parameters, in Meadows' terminology (Meadows, 2008[3])- see below), but can also, for example, pull the plug and reduce stocks that lock systems into undesired equilibriums (e.g. road reallocation, see more below). Cognitive science argues that our brain prefers to add rather than subtract (Adams et al., 2021[31]). This biological tendency may help explain why most policies focus on parameters (opening or closing faucets) rather than on reducing undesired stocks (pulling the plug).

Meadows' leverage points framework combines insights from CLDs and stock and flow analysis to identify 12 places to intervene in complex systems, referred to as "leverage points" (Meadows, 1999[32]) (Figure 3.14). High-leverage points are places in which a small intervention may lead to large behavioural changes. Low-leverage points are places in which small interventions lead to small changes. The leverage points can be mapped onto the four levels of the iceberg model, with the leverage point with the lowest potential to trigger change (the 12th) at the tip of the iceberg and the leverage point with the highest potential at the very bottom. More information on the framework is available at (Meadows, 1999[32]), and the categorisation of Irish policies using Meadows' 12 leverage points is available in the database in Annex C.

Figure 3.14. Leverage points on the iceberg model



Source: (Systems Innovation, 2021[33]), adapted from (Meadows, 1999[32]).

In this report, Meadows' framework guides the assessment of policies' transformative potential as follows:

- Policies that address leverage points 10 to 12 (top of Figure 3.14) aim to reduce harmful results but do not affect the underlying system structure. They are classified in this report as policies with low transformative potential. Examples are actions that limit or regulate the force of a certain flow, e.g. air quality or fuel efficiency standards regulate the force with which cars produce air pollution or GHG emissions. The expansion of stocks relative to the flows produced in the system is another type of action in this category. Meadows calls these actions "buffers", since making a stock larger relative to a flow can allow the system to cope better with the negative consequences of the existing system. Again, these actions do not address the causes of the flow. A good example of a buffer is the widening and expansion of roads to cope with the growth in traffic.

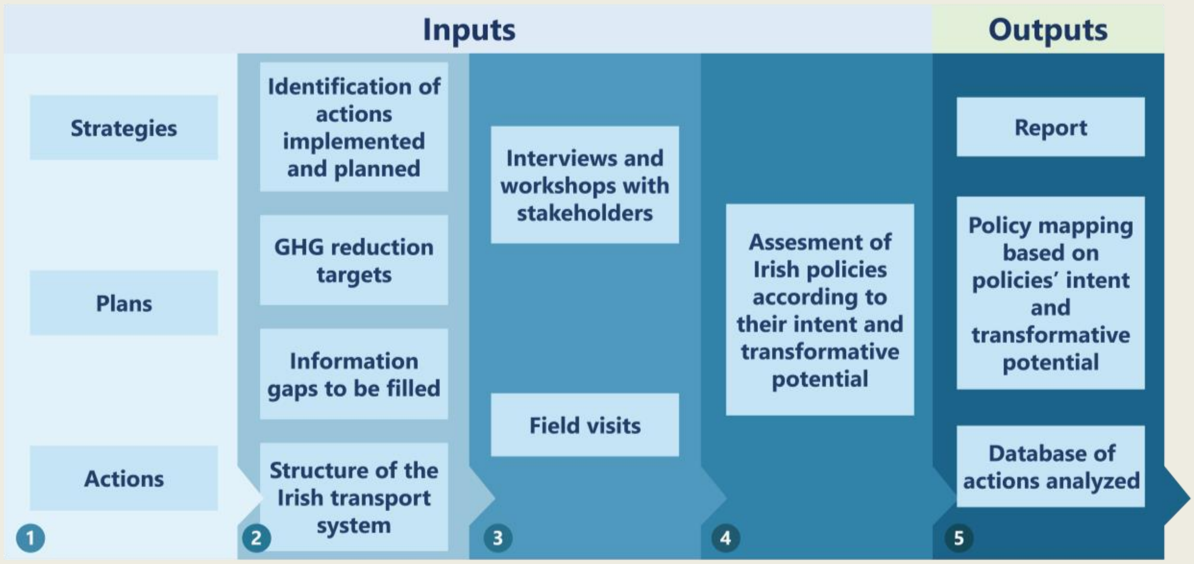
- Policies that address leverage points 7 to 9 affect the system structure by strengthening or weakening feedback loops, but they do not flip the basin of attraction (see Box 3.2). They are classified in this report as policies with medium transformative potential. Examples include investment in public transport to make this mode more attractive and weaken the sustainable modes low-attractiveness trap (see section 3.1) in car-dependent systems in which the dynamic of induced car demand continues to dominate.
- Policies that address leverage points 4 to 6 contribute to shifting away from unsustainable dynamics, transforming the system structure. They are classified in this report as policies with high transformative potential. Examples include actions that change the rules of the system (e.g. to whom and what uses public space is allocated), the criteria of success (e.g. in appraisal methodologies), or the feedback loop structure of the system (e.g. liberated space via road reallocation can restructure the way transport modes are organised).
- Policies that address leverage points 1 to 3 affect the mental models underlying system design. They are classified in this report as policies with high transformative potential. Examples include actions that establish and mainstream a new goal for the system (see the discussion of this in Chapter 2) and communication efforts challenging the car-centric paradigm.

The following section uses this classification to identify the transformative intent and potential of specific Irish policies.

Box 3.3. Data-gathering process, tools and outputs

Data was gathered via desk reviews, interviews and workshops with Irish stakeholders. First, the strategies, plans and actions to be included in the assessment were identified (Figure 3.15). The strategies and frameworks analysed included the National Planning Framework, National Development Plan, National Sustainable Mobility Policy, Climate Action Plan, Sustainable Mobility Policy, National Investment Framework for Transport in Ireland (NIFTI) and Common Appraisal Framework for Transport. The list of actions assessed is available in Annex C. Second, desk reviews were carried out, enabling the research team to identify and gather information on the actions being implemented and planned, the GHG reduction targets set, the structure of the Irish transport system, and the remaining information gaps. Third, interviews and workshops with Irish stakeholders and field visits to Dublin, Cork, Kildare and Sligo were carried out to fill these gaps. Fourth, the intent and transformative potential of planned and implemented Irish policies were assessed based on the framework described in this section.[1]

Figure 3.15. Data-gathering process, tools and outputs



[1] This process also informed the first step, "Envision", described in Chapter 2. The desk reviews, interviews and workshops shed light on what a better transport system would look like, the proxies used to measure success and guide policy decisions, and the assumptions that remain unquestioned.

3.2.2. Applying the framework: policy assessment results

Drawing on the framework just described, this section assesses the intent and transformative potential of implemented and planned policies in Ireland for the surface passenger transport sector. The assessment groups Irish individual actions into eight categories: EV incentives for private cars; budget reallocation in favour of public transport and active modes relative to car; brownfield/infill targets; efforts to improve public transport and active modes; carbon and road pricing; road space reallocation; mainstreaming of on-demand shared services; and communication efforts. A table with the assessment of selected individual actions analysed is available in Annex B. The list of selected actions is not comprehensive of everything being done by Ireland[6]. Rather the table takes some of the actions highlighted in different documents with the purpose of showing how the framework can apply to analysing disaggregated actions. The exercise shows that while some individual actions (e.g. adding specific infrastructure) might have a lower power, when taken as part of a policy category (e.g. efforts to improve public transport and active modes) their power might be higher.

The assessment finds that the policies with the highest transformative potential are mostly implemented at a pilot or very small scale. These policies, if prioritised and scaled up, could unleash huge emission reduction potential and help Ireland meet its ambitious GHG reduction targets on time.

Figure 3.16 provides a snapshot of the assessment results on the iceberg model, according to their transformative potential in car-dependent transport systems. A number of policies receiving high attention and funding[7] in Ireland – EV incentives for private vehicles, 2:1 budget allocation to new public transport infrastructure versus new roads, infill development targets, and carbon pricing – have low transformative potential. These policies react to or anticipate the negative consequences of car-dependent systems but do not transform them (sometimes the reverse, in fact). As a result, the system is still fostering car use (see sub-sections below).

The analysis suggests that road space reallocation, the mainstreaming of on-demand services, and communication efforts have the highest potential to reverse car dependency and reduce emissions via a just transition. If scaled up, these policies can transform the system structure to change patterns of behaviour.

Figure 3.16. Irish policies classified by transformational potential and intent

Note that the positioning and colour-coding of policies on the iceberg do not determine whether a policy is good or bad. Policies at the top of the iceberg may still be fundamental (e.g. carbon and road pricing policies are necessary to finance and accelerate the transition). This assessment aims to show that policy packages which only react to or anticipate undesired patterns of behaviour without transforming the system structure are unlikely to change those patterns in the future. A rebalancing of efforts towards transformative policies is needed.

The rest of this chapter presents the detailed results of the assessment for each policy type, outlining the intent of the policy type and its transformative potential in terms of the effect on the system feedback loops, physical stocks and mental models (where relevant) underlying car dependency.

EV incentives for private cars

Ireland relies heavily on incentives[8] for private cars and support for electric (including traditional and plug-in hybrid) vehicles to deliver the GHG emission reductions it envisions by 2030 for its transport sector. 40% of Ireland's transport GHG emission reductions by 2030 (according to the Climate Action Plan 2021 (Department of the Taoiseach Ireland, 2021[1])) are expected to come from an increase in the uptake of electric private passenger cars, fostered by EV incentives. Overall, Ireland aims for 67% of GHG emission savings to come from different types of vehicle technology and fuel improvement (Department of the Taoiseach Ireland, 2021[1]).

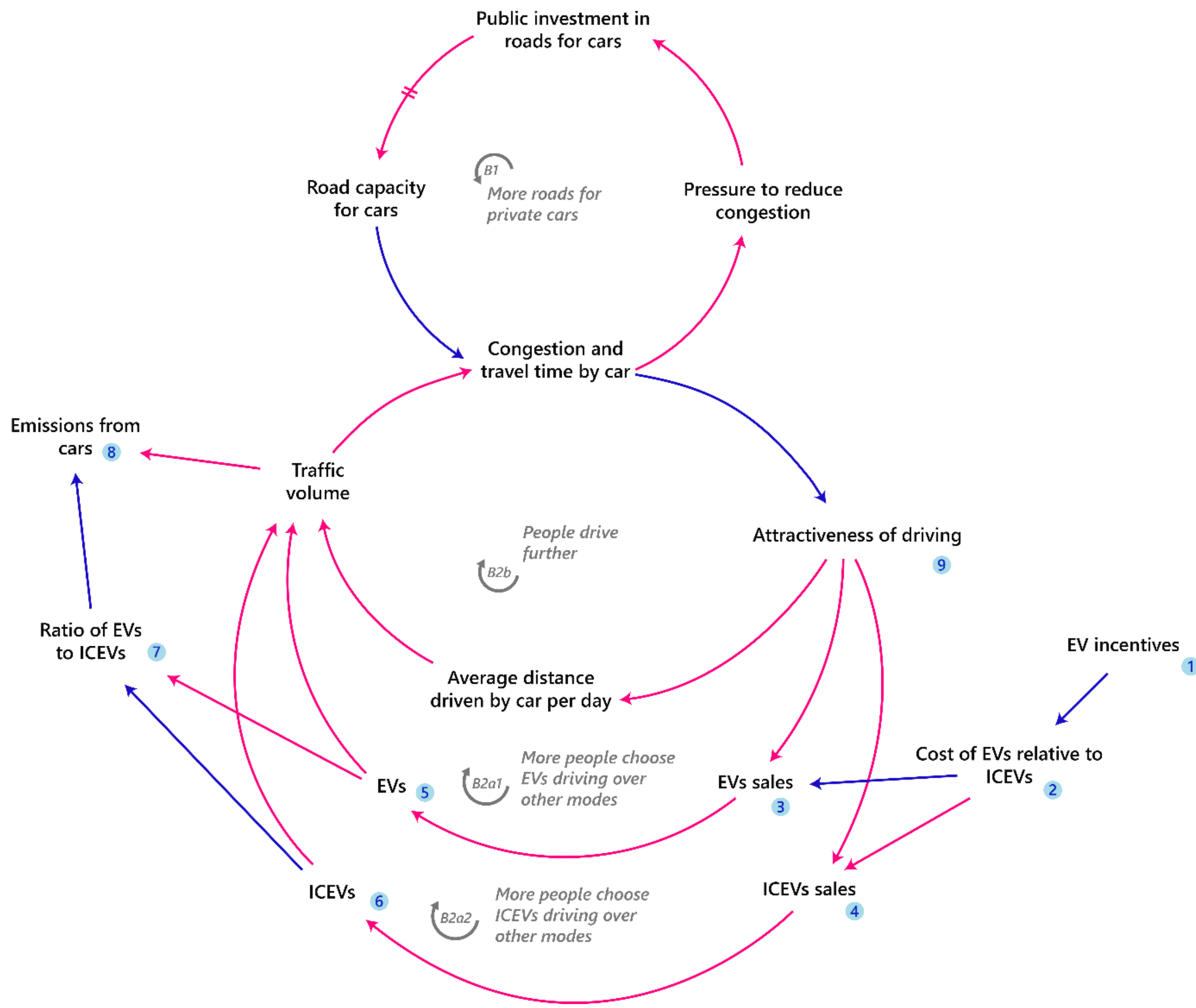
EV incentives are included in the Climate Action Plan as one of the cross-cutting policies to reach 2030 targets (along with carbon pricing and other CO_2-based taxes) (Department of the Taoiseach Ireland, 2021[1]). They include subsidies for EV purchase and ownership (grants and tax relief for consumers and businesses), exemptions from benefit-in-kind taxation of company cars, and charging station grants (Department of Transport Ireland, 2022[34]; Department of the Taoiseach Ireland, 2021[1]; Parliamentary Budget Office Ireland, 2022[35]). According to the Parliamentary Budget Office (2022[35]), 322.42 million euros were provided between 2010 and 2021 to support the various schemes focused on lower emitting vehicles: battery electric vehicles, plug-in hybrid electric vehicles, traditional hybrids, alternatively fuelled vehicles, and for charging grants. Vehicle registration tax relief during the same period amounted 166.6 million euros; divided between conventional hybrids (64.4 million euros), plug-in hybrids (26.8 million euros), and battery-electric vehicles (75.4 million euros).

The rest of this section presents the detailed results of the assessment for EV incentives, based on the framework described in section 3.2.1. The section outlines the intent of the policy type and its transformative potential in terms of the effect on the system's feedback loops, physical stocks and mental models underlying car dependency. Based on this analysis, EV incentives for private cars are anticipatory policies and have low potential to transform the current car-dependent system (Figure 3.16). EV incentives are anticipatory policies as they assume – and aim to anticipate the negative consequences of – continued growth in car use. They have a low potential to transform car-dependent systems because (as shown in the next sub-sections) the incentives leave the car-dependent structure of the system intact and may lock it in further by reinforcing induced car demand, urban sprawl, car-centric mental models and the belief that changes in technology are sufficient to achieve climate targets (potentially undermining political support for transformative climate policies). Furthermore, the analysis finds that the emission reduction expectations related to increased EV uptake in Ireland may not fully recognise the rebound effect and the difficulty of replacing large and growing vehicle fleets, which are hard and slow to change.

EV incentives for private vehicles do not transform and may reinforce the dynamic of induced car demand. Figure 3.17 replicates the dynamic leading to growing car use (induced car demand) introduced in section 3.1.1 to illustrate that EV incentives do not transform and may reinforce these dynamics. EV incentives (1 in Figure 3.17) decrease the cost of EVs relative to ICEVs (internal combustion engine vehicles) (2) via grants or tax relief and by providing easily accessible charging infrastructure for private vehicles. The cost of EVs relative to ICEVs (2) is reduced, which fosters EVs sales (3) and reduces ICEVs sales (4) (ceteris paribus). Vehicle sales affect the number of EVs (5) and ICEVs (6) in the vehicle fleet, and thus the ratio of EVs to ICEVs (7).

Note that EV incentives affect the properties of the car fleet in terms of the type of vehicle sold. This can reduce local emissions from cars (8) but do not transform the dynamic of induced car demand at the source of growing car use: cars remain the most attractive mode, and thus the mode that most people choose for the bulk of their trips. Moreover, by reducing the cost of driving and owning a car[9], EV incentives (1 in Figure 3.17) may increase the attractiveness of driving a car[10] (9) and further lock in the dynamic of induced car demand, leading to growing car use.

Figure 3.17. The effect of EV incentives on induced car demand



Note: The coloured arrows show the relationship between variables. A pink arrow between variables means that they vary in the same direction: an increase in a variable leads to an increase in the variable it points at; a decrease in a variable leads to a decrease in the variable it points at. A blue arrow means that variables vary in the opposite direction: an increase in a variable leads to a decrease in the variable it points at; a decrease in a variable leads to an increase in the variable it points at. Each loop label (e.g. B1) denotes a feedback loop. A feedback loop is either reinforcing (R), or balancing (B). See Box 3.1 and section 3.1 for more information on how to read causal loop diagrams.

The rebound effect may reduce the benefits of EV incentives in terms of emission reductions

The growing car use that may arise from increased attractiveness of driving a car increases the risk of a rebound effect[11] (Orsi, 2021[36]). Kampman et al. (2011[37]) developed EV scenarios for Europe and found that "funding, subsidies and non-financial incentives for EVs can create a rebound effect, where total passenger transport increases compared to the status quo". They find that this effect may increase congestion, energy consumption and GHG emissions. Orsi (2021[36]) estimates that a household's mileage could increase up to 18% due to the operation cost advantages of EVs. In addition, Caulfield, Carroll and Ahern (2020[12]) point out that in order to be competitive for buyers and provide positive payback, an EV needs to be used more than an ICEV, providing a further incentive for EV owners to drive more. Incentives such as the benefit-in-kind tax exemptions for EV company cars may also lead to an increase in the number of employees accessing (and intensively using) company cars.

Worryingly, the rebound effect and its associated costs in a future where car dependency persists are misrepresented (and sometimes ignored) in modelling and appraisal exercises. For example, the Irish national transport demand models do not capture the long-term feedback loops connecting transport policy, infrastructure development and land-use changes.

EV incentives may reinforce urban sprawl

EV incentives may also foster urban sprawl. As the cost of driving is reduced, EVs may reinforce the attractiveness of detached and large houses in the outskirts and lead to more built-up land surface (Orsi, 2021[36]). Ireland's regulation of private EV charging and car parking could aggravate this. The provision of EV charging in dwellings with parking spaces within their curtilage[12] – an action in the Climate Action Plan – can perpetuate car dependency and sprawl via requirements for private-car parking and charging in new developments. A development that needs a certain amount of car parking (now potentially with charging infrastructure) is more space-intensive and expensive, which means that more space needs to be used to deliver more housing, and housing in the outskirts (where land is cheaper) is further incentivised (OECD, 2021[10]). In Ireland, many counties (e.g. Sligo) have not shifted from minimum to maximum parking standards for new developments, and national legislation is vague in this respect.

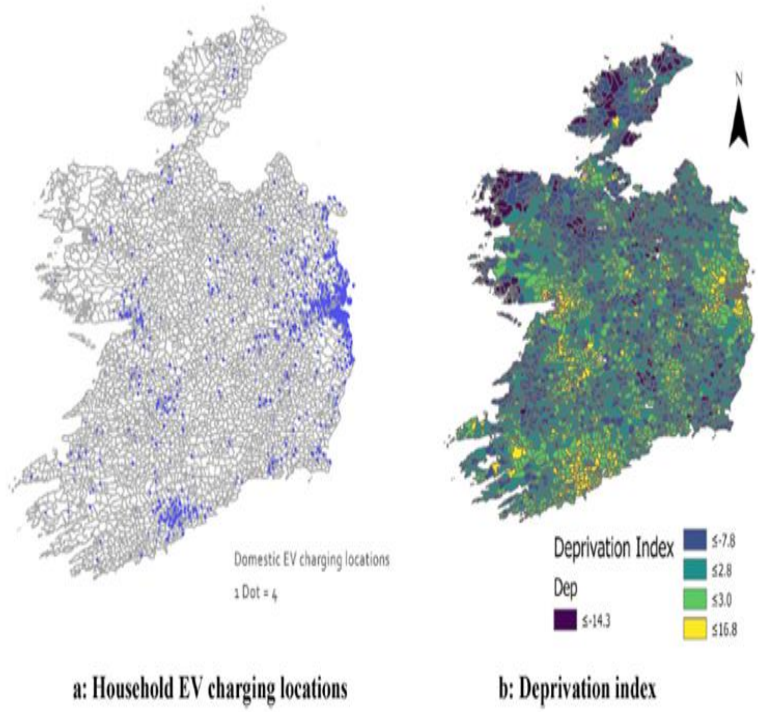
EV incentives may reinforce car-centric mental models and the idea of an unjust green transition

With respect to mental models, EV incentives, coupled with a climate strategy assuming that 67% of the ambitious emission reduction target for the sector can result from better vehicles and fuels, can reinforce the belief that the transport system is fit for purpose and that changes in technology are sufficient to achieve the targets – which evidence suggests is not the case (IPCC, 2022[25]). While it may seem minor, reinforcing this belief may undermine the political support, and thus the feasibility, of transformative policies, which may be perceived as requiring an unnecessary effort or lifestyle change. EV incentives and related communication can also give the false impression that, as long as it is electric, increased car ownership and use is not a problem. In fact, demand for electric car travel needs to be managed to reduce the cost of Ireland's energy grid upgrades and to reduce air pollution (to be discussed in section 4.5). Research suggests that reducing energy demand, including through reduced car travel, makes the Irish net-zero target achievable at substantially lower costs (Gaur et al., 2022[38]). Provision for private car parking and charging can also reinforce the idea that everyone is entitled to have a private car and a dedicated space for it, and that the duty of the government is to facilitate ease of use, further reinforcing car-centric mindsets.

The idea that the green transition is unjust may also be reinforced by EV-centric climate strategies. Public spending on EVs is rapidly accelerating (Parliamentary Budget Office Ireland, 2022[35]). Government incentives, however, predominantly benefit high-income households and businesses, who can afford new vehicles and the switch to an EV (Society of the Irish Motor Industry, 2022[39]; Parliamentary Budget Office Ireland, 2022[35]). Lower-income households may lack the savings to buy a new car (Aryanpur et al., 2022[40]). For households in rented accommodation and apartments, access to charging can be an additional barrier to EV adoption (Caulfield et al., 2022[41]; Mukherjee and Ryan, 2020[42]).

Early EV car owners in Ireland are concentrated in suburban neighbourhoods around the cities, in areas with higher home ownership, income, education and age (Figure 3.18) (Caulfield et al., 2022[41]; Mukherjee and Ryan, 2020[42]). Areas with higher levels of car ownership have more EV home charging points installed, indicating that EVs may represent a household's second or third car (Caulfield et al., 2022[41]). This aligns with Norway's experience, where buyers of battery-electric vehicles were found to be more likely to expand their household's car ownership than other car buyers (Bauer, 2018[43]).

Figure 3.18. EV home chargers concentrated in well-off suburbs around Ireland's largest urban areas



Source: (Caulfield et al., 2022[41]), doi.org/10.1016/j.energy.2022.123588.
Note: In order to investigate these phenomena, this article will look at the effects that employment decisions and levels of affluence have on the distribution of charging stations in Ireland. An indicator of relative prosperity and deprivation obtained from the Census was used to quantify this. This deprivation index calculates an overall index by taking into account variables including social class, educational attainment, employment status, and household type.

EV replacement may take longer than expected

Widespread electrification in the car fleet is a slow process (Brand and Anable, 2019[44]) and incentivising high shares of EVs in sales is challenging and costly. The stock and flows analysis in this report suggests that the emission reduction expectations related to increased private EV uptake stimulated by incentives may not fully incorporate the difficulty of replacing large and growing vehicle fleets. Furthermore, the current EV target in Ireland, set in terms of the number of electric vehicles sold (845,000 electric vehicles in the Irish passenger car fleet by 2030 (Department of the Taoiseach Ireland, 2021[1])), may set the wrong incentives as the more vehicles sold in total, the easier it is to achieve the target (see discussion on revisiting targets in Chapter 4).

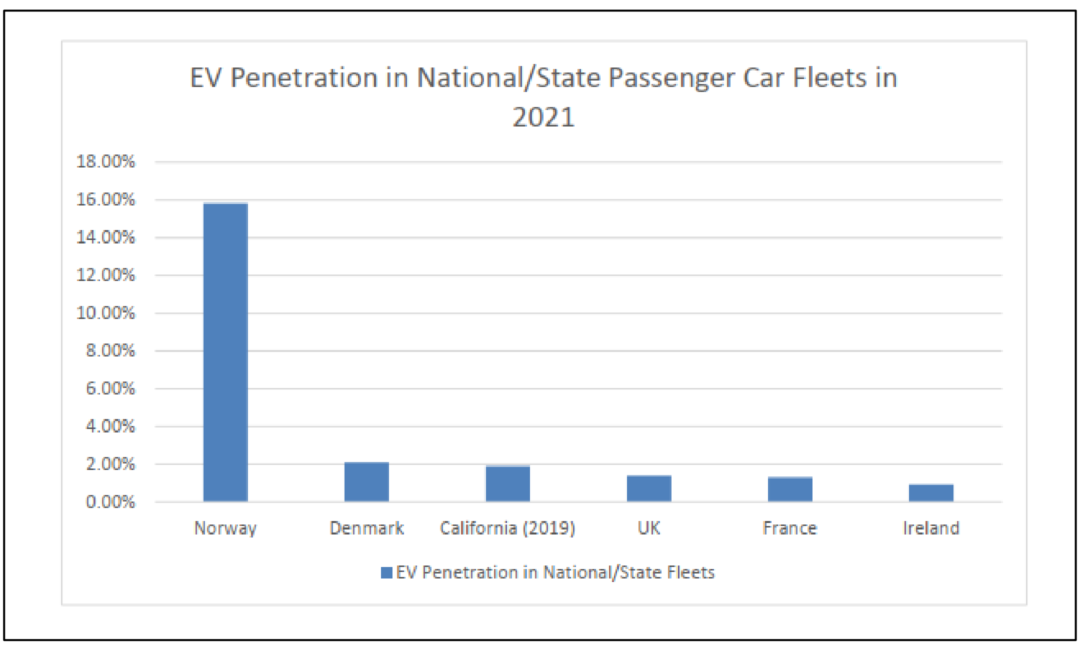
Car fleets are what is referred in Meadows' leverage framework as a "hard to change stock". New car sales are flows and the vehicle fleet is the stock that accumulates through time via car sales. Even if the sale of new combustion vehicles were banned tomorrow, and those sales were entirely replaced by EV sales, it would still take time for the fleet in the country to be predominantly electric. This is because the stock of combustion vehicles is high and cars are expensive goods that last for decades: the usage period of a car is approximately 13 years in Ireland (Society of the Irish Motor Industry, 2022[39]).

For this reason, even when Ireland has seen a steady increase in EV registrations, this is not enough to ensure that EVs will make a large part of the fleet (and reduce emissions at a fast pace) in the near future. The Irish fleet in 2022 counts around 2.2 million cars, 97% of which are combustion-based (i.e. gasoline or diesel) due to decades of combustion vehicle sales. Private EV sales have experienced a steady increase since 2016 (Dowling, 2022[45]). In 2019, EV car sales (including hybrid and plug-in hybrids) accounted for 4% of total sales. In 2021, they accounted for 8% of total sales (Industry, Society of the Irish Motor, 2022[46]), and more recent statistics show 10,105 electric vehicles were registered in the first 7 months of 2022 – accounting for 21% of the sale shares during such period (RTÉ, 2022[47]). While this is a positive trend, still 79% of new private vehicles sold in the first half of 2022 were ICEVs, vehicles which will likely remain for approximately 13 years as part of the Irish vehicle fleet.

Furthermore, total car sales are growing, and thus a higher share of EVs does not necessarily imply that the absolute number of new ICEVs into the fleet will be smaller than in the past. For example, in 2021, 8,646 new EVs entered the fleet. Yet, total new car registrations were 104,932; meaning that 96,286 new ICEVs also entered the fleet (Industry, Society of the Irish Motor, 2022[46]). Registrations to date (September) are up by 2.1% in 2022 compared to 2021 (Industry, Society of the Irish Motor, 2022[46]) and Transport Infrastructure Ireland ((2019[11]), accessed from (Caulfield, Carroll and Ahern, 2020[12])) estimates that the total fleet of private vehicles would continue to rise 30% by 2030 (compared to 2016). The Department for Transport estimates that meeting the current EV target would require that by 2029 the share of EV sales reaches 100%, while the increase in the size of the 'on-the-road' fleet between 2019 and 2030 remains below 6.44%[13] (Department of Transport, 2022[48]).

The case of Norway provides a good illustration of the slow pace at which electric vehicle sales (despite reaching high levels) translate into electric vehicle shares in the total fleet. Norway is the global front-runner in incentivising EV sales. It has provided generous tax rebates for EVs over many years (Lévay, Drossinos and Thiel, 2017[49]), and EV incentives are mainstreamed into the country's fiscal system (OECD, 2021[10]), in which CO_2-related taxes are equivalent to a carbon tax higher than 1 250 euros per tonne. Despite years of large EV sale shares[14] (e.g. over three times the shares attained in Ireland in the first half of 2022), only 16 out of 100 cars in circulation were electric in Norway in 2021 (Department of Transport, 2021[50]) (Figure 3.19). The majority of the fleet (over 80%), remains fuel based.

Figure 3.19. A slow-to-change stock in selected countries



Source: (Department of Transport, 2021[50]), https://www.gov.ie/en/publication/e62e0-electric-vehicle-policy-pathway/

In line with this, different world scenarios also indicate that attaining high shares of EVs in total fleets before mid-century is unlikely. For instance, the EIA projects in its International Energy Outlook 2021 that EVs (including hybrids) will account for 31% of private vehicles in 2050 worldwide, which corresponds to a share of 34% in OECD and 28% in non-OECD countries. According to the IEA, under the assumption that governments accelerate efforts in its Sustainable Scenario, the global EV fleet will reach a 12% share by 2030 (IEA, 2022[51]). This is in line with findings from Caulfield, Carroll and Ahern (2020[12]) (2020[12]), which indicate – assuming the cost of EVs and ICEs reach parity by 2035[15] – that by 2040, EVs would account for only 11-28% of the world fleet (Caulfield, Carroll and Ahern, 2020[12]).

Among the many uncertainties around EV sales, and the cost that accelerating their uptake will entail, is the question of ICEV and EV parity. Some studies are more optimistic compared to (Caulfield, Carroll and Ahern, 2020[12]) (see above); indicating this could be earlier (2025) (Szymkowski, 2021[52]; Soulopoulos, 2017[53]). Yet some others, like the MIT Energy Initiative (2019[54]), consider that "a mid-sized battery electric vehicle with a range of 200-plus miles will likely remain upwards of $5,000 more expensive to manufacture than a similar internal combustion vehicle through 2030 [and] …the manufacturing cost differential between electric and conventional vehicles is expected to persist well beyond 2030". Although the MIT Energy Initiative (2019[54]) (2019[54])also mentions that lower operational costs could offset part of the differential, there seems to be relevant differences between vehicle types. For instance, a case study focusing on the US market highlights that the year for price parity varies between sedans and SUVs (Archsmith, Muehlegger and Rapson, 2021[55]). Price parity between EV SUVs and ICE SUVs is estimated to be reached only by 2040 (Archsmith, Muehlegger and Rapson, 2021[55]) – 10 years *after* median estimates for the sedan. Such differences are relevant for the case of Ireland, where SUVs[16] accounted for half of new car registrations in Ireland in 2021, up from 24% in 2015 (Society of the Irish Motor Industry, 2022[16]). The uptake of SUVs is also problematic for other reasons (space occupied, larger damage to roads, material use, etc.). Moreover, parity is not the only element that is relevant for ensuring uptake. For instance, the lack of availability and choice of models have been identified as barriers to increasing uptake according to Caulfield, Carroll and Ahern (2020[12]), along with price. Charging infrastructure (discussed in detail in chapter 4) is also relevant.

An additional problem is that, as reflected by statistics by the Parliamentary Budget Office Ireland (2022[35]), traditional and plug-in hybrids are being included in the incentives granted by the government for incentivising technological change in private car use. Not surprisingly, a lot of these vehicles are entering the fleet and constitute larger shares of sales than battery electric cars. For example, new car registrations show that in 2021 the sales share of traditional hybrids was much higher (16.22%), compared to that of battery-electric vehicles (8.24%). The share of plug-in hybrids was also 7.26%. Traditional and plug-in hybrid electric vehicles have shown a particularly large gap between laboratory (i.e. registered) and on-road (i.e. real) emissions. Studies conducted taking the most popular PHEVs in Europe show that emissions can be up to 8 times higher than registered emissions (for the least efficient vehicles) and up to 12 times higher when the vehicle is designed to do geo-fencing (i.e. when the engine can recharge the battery) (OECD, 2021[10]). Thus, including plug-in and traditional hybrid vehicles as part of EV incentives can, in addition to hindering emission reductions due to reinforcing car-dependency (see above), further delay the effect of technological change by incorporating vehicles into the fleet that have much higher tail-pipe emissions than expected (OECD, 2021[10]).

Budget reallocation in favour of public transport and active modes compared to car infrastructure

The Climate Action Plan (CAP) 2021 includes improvements for public transport and active modes among the measures to reduce GHG emissions in the transport sector (Department of the Taoiseach Ireland, 2021[1]). Together with demand management measures for ICEVs (see "Carbon and road pricing" section), more sustainable travel (with a target of 500 000 additional journeys by public transport and active modes per day by 2030) accounts for approximately 23% of the CAP's GHG emissions targets for the transport sector (Department of the Taoiseach Ireland, 2021[1]).

Following recommendations from a citizens' assembly, the Irish government has introduced a 2:1 investment allocation ratio between public transport and road infrastructure: for every euro spent on road infrastructure, two are spent on public transport infrastructure. The Government has also earmarked a share of its transport budget for active modes. The transport budget for the period 2021–2030 allocates 46% of funding to public transport (15.7 billion euros), 11% to active modes (3.6 billion euros) and 43% to roads for car use (14.8 billion euros). 78% of the budget for public transport is allocated to new public transport infrastructure (11.6 billion euros). Out of the budget for roads for cars, 39% is allocated to new road infrastructure (5.8 billion euros), fulfilling the 2:1 allocation ratio (11.6 billion euros for new public transport infrastructure and 5.8 billion euros for new road infrastructure) (Department of Transport, 2021[56]).

The rest of this section presents the detailed results of the assessment for budget reallocation towards public transport and active modes, based on the framework described in section 3.2.1. The section outlines the intent of the policy type and its transformative potential in terms of the effect on the system feedback loops, physical stocks and mental models underlying car dependency. Based on this analysis, the planned budget reallocation has mixed intent and low potential to transform the current car-dependent system (Figure 3.16). In terms of its intent, on the one hand, the policy has the transformative intent of reducing the attractiveness gap between cars and public transport; on the other hand, it assumes and anticipates continued growth in car use and thus plans new road construction, reinforcing the idea that more roads will continue to be needed. In terms of its transformative potential, the current budget reallocation, while useful to slow down the sustainable modes low-attractiveness trap dynamic, is unlikely to reverse it and close the attractiveness gap between modes (see detail below).

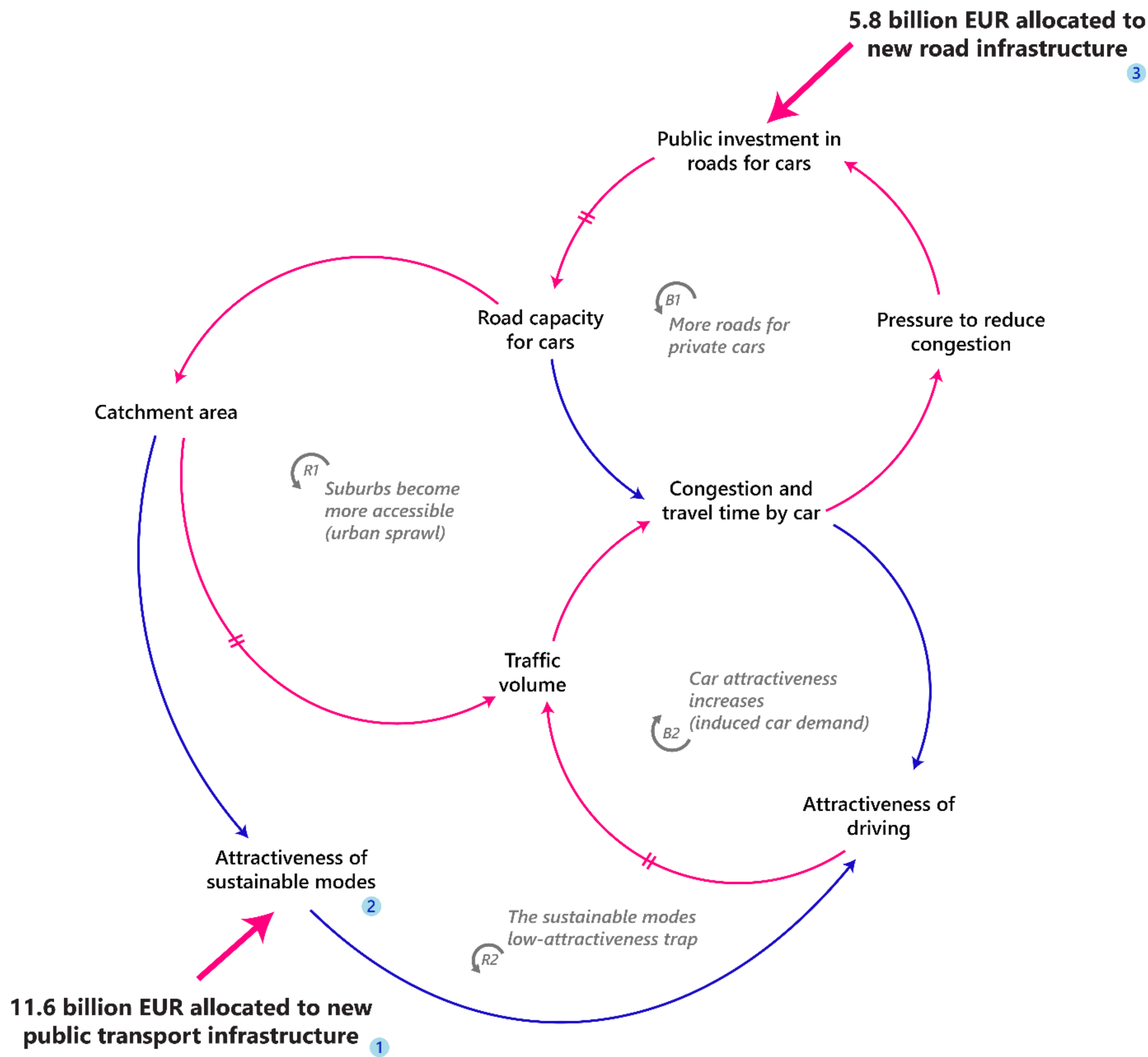
The budget reallocation may slow down the sustainable modes low attractiveness trap, but is unlikely to reverse it

As explained above, the transformative impact of policies greatly depends on the history and current state of the system. Decades of budget allocation favouring cars have led to an accumulation of road capacity for car use and a lag in the infrastructure for the use of public and active modes. For instance, between 2006 and 2019, the ratio of investment in Ireland (total, not only new infrastructure) was 2 to 1 in favour of roads for cars (OECD, 2021[57]) (Figure 3.21). Also, the behavioural change that improvements in public transport and active modes may trigger depends to a great extent on the attractiveness gap between car driving and other modes. In the case of Ireland, this gap is high: for example, the inner city of Dublin has 80 shops on average that are accessible within 15 minutes by car, but only 36 by public transport and 18 on foot (ITF, 2022[58]).

Furthermore, while funding for public transport and active modes makes them more appealing, funding for car use keeps reinforcing induced car demand, and (at least partially) offsets improvements in public and active modes[17] (Figure 3.20). The fact that the budget reallocation is set as a ratio implies that, in principle, a higher investment for public transport also entails a higher investment for car-infrastructure; which means this off-setting of efforts for improving public and active mode is likely to keep on happening.

If implemented decades ago, a budget reallocation like the one currently planned could have created virtuous dynamics towards sustainable modes. However, after decades of public investment favouring car use, and given the urgency of the situation, efforts to improve public transport and active modes need to be quantitatively more ambitious and also qualitatively different. Reallocating public space (described in greater detail later in this section) is one example of a qualitatively different action. Rather than affect flows (open or close faucets, using the bathtub analogy introduced in section 3.1), road space reallocation (see more below) can reduce an existing stock (pull the plug of the bathtub) that is key to the car-dependent system's functioning: the large stock of infrastructure allocated to car use.

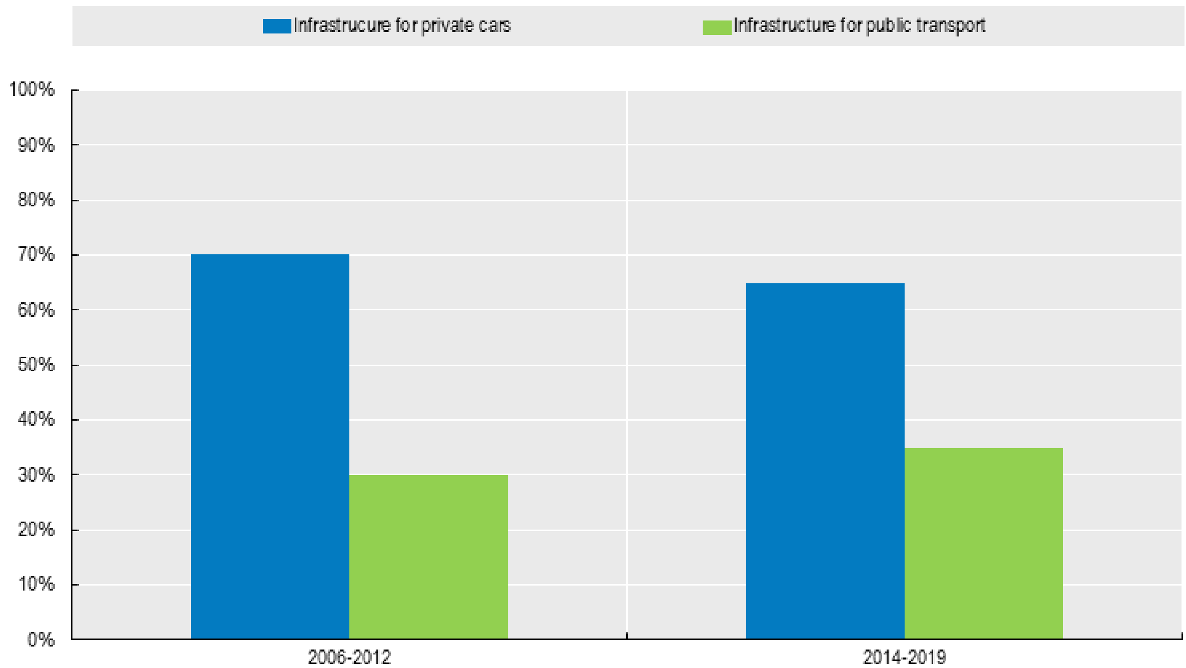
Figure 3.20. The effect of budget reallocation on the system dynamics underlying car dependency



Note 1: The 11.6 billion EUR allocated to new public transport infrastructure (1) can increase the attractiveness of sustainable modes (2) vis-à-vis the car, and thus encourage people to choose sustainable modes more frequently. In parallel, the 5.8 billion EUR allocated to public investments in new road infrastructure (3) can reinforce the dynamics of induced car demand (B2), urban sprawl (R1), and the sustainability modes low-attractiveness trap (R2).

Note 2: The coloured arrows show the relationship between variables. A pink arrow between variables means that they vary in the same direction: an increase in a variable leads to an increase in the variable it points at; a decrease in a variable leads to a decrease in the variable it points at. A blue arrow means that variables vary in the opposite direction: an increase in a variable leads to a decrease in the variable it points at; a decrease in a variable leads to an increase in the variable it points at. Each loop label (e.g. B1) denotes a feedback loop. A feedback loop is either reinforcing (R), or balancing (B). See Box 3.1 and section 3.1 for more information on how to read causal loop diagrams.

Figure 3.21. Budget allocation in Ireland for infrastructure for private cars and public transport (share of total, 2006–2019)



Source: Authors, based on (OECD, 2021[57]), https://doi.org/*10.1787/9ef10b4f-en*

The budget reallocation still reflects car-oriented planning

Finally, efforts to improve public transport and active modes without a profound shift in mindset may produce only short-lived change. The 2:1 ratio implies that roads still need to be expanded systematically. Commitment to the need for more roads is evident from the fact that, in an effort to meet the 2:1 target, a number of road projects were postponed (by five years) rather than cancelled. Such projects remain in the pipeline and may be reactivated if road infrastructure is still seen as the main means to curb congestion. Revising appraisal methodologies could help avoid bias in favour of mobility-oriented policy decisions and foster accessibility-centred decision-making in the future. In this regard, the new SMP includes as an explicit action the updating of the Common Appraisal Framework for Transport Projects and Programmes (CAF). In parallel, the Department of Public Expenditure and Reform is reviewing the Public Spending Code with the aim of strengthening the government's capacity to account for environmental aspects (including climate risks and uncertainty) in the public investment decision-making process (Department of Transport, 2022[59]).

Brownfield/infill development targets

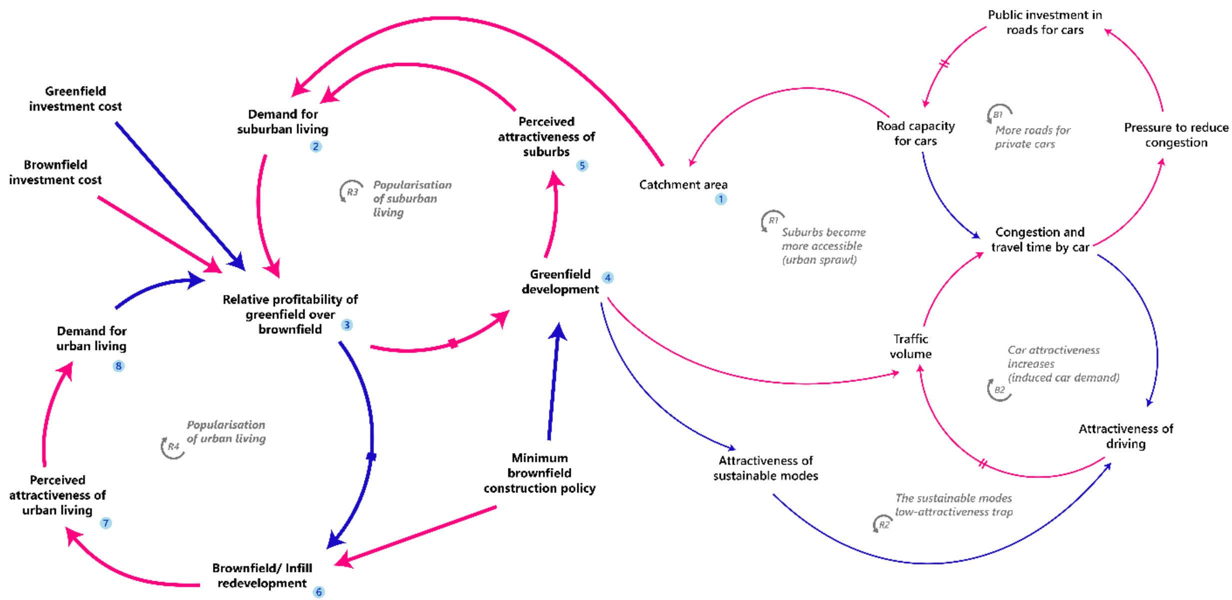
Housing development trends in Ireland show a clear dominance of greenfield development, in the form of detached and one-off[18] housing in the outskirts and countryside around cities and towns. Between 2002 and 2016, detached houses (typically built outside of city and town centres due to the space they require) represented a steady share of around 45% of housing, while semi-detached houses accounted for around 28% (CSO, 2016[60]). In 2016, 98% of one-off houses were outside towns or settlements,[19] with 65% located within one to five kilometres of towns or settlements and 15% more than five kilometres away (CSO, 2016[60]).

Ireland has recently set a target (via its National Planning Framework) for 40%[20] of new construction in urban areas to be built on brownfield/infill [21] sites (Government of Ireland, 2018[61]; Dept of Rural and Community Development and Dept of Housing Local Government and Heritage, 2022[62]). The aim is to limit development in greenfield areas[22], since this form of development fosters urban sprawl and is associated with higher infrastructure costs and emissions than brownfield development (Wilson and Chakraborty, 2001[63]; OECD, 2018[17]; Rubiera-Morollón and Garrido-Yserte, 2020[64]). While the Climate Action Plan (CAP) does not allocate a specific share of emissions reduction to increasing brownfield development, it does specify that the 40% target for brownfield/infill development should be fully achieved by 2040 (Department of the Taoiseach Ireland, 2021[1]). A number of stakeholders interviewed or participating in the April 2022 workshops considered brownfield/infill targets as one of the key measures taken by the government to address sprawl.

The rest of this section presents the detailed results of the assessment for brownfield/infill development targets, based on the framework described in section 3.2.1. The section outlines the intent of the policy type and its transformative potential in terms of the effect on the system feedback loops, physical stocks and mental models underlying car dependency. Based on this analysis, the brownfield/infill development targets have an anticipatory intent and a low transformative potential Figure 3.16. The policy has an anticipatory intent as it assumes that developers and the population[23] will continue to prefer greenfield development and imposes limits in order to reduce the negative consequences of that pattern. It has a low transformative potential in the current car-dependent system because the target does not address the reasons for the greater attractiveness of greenfield development (see more below) and still allows for 60% of urban development and 70% of rural development to take place in greenfield areas (Government of Ireland, 2022[65]), thus enabling urban sprawl to continue (Figure 3.22).

As shown in Figure 3.22, the relatively high profitability of greenfield development over brownfield development is an important factor behind continued sprawl. Greenfield development is currently more profitable than brownfield development because of many reasons. Among the most relevant is the fact that land prices (and thus investment costs) are lower on the outskirts, and because developing in empty areas is often technically easier and cheaper than refurbishing existing buildings or sites. There are large cost differences in the site itself as well as in construction costs, which together constitute more than half of the overall development costs. For example, the cost of a site for a medium-rise apartment building in a suburban greenfield area is between €46 000 and €59 000, while construction costs (including substructures, external site works, and elements of the building itself) vary from €191 000 to €253 000. The site purchase and construction costs for a similar building on an urban brownfield site are €65 000–80 000 and €219 000–262 000, respectively (SCSI, 2021[66]). Calculations by SCSI (2021[66]) show that delivering a new two-bedroom apartment on a greenfield site in a suburban area is more profitable than delivering the same property on a brownfield site in an urban area.[24] The suburban development produces a profit margin of 16 to 21%, while that of the urban development is 11 to 13%.

Figure 3.22. The effect of brownfield/infill development on the system dynamics underlying car dependency



Note 1: With an increasing catchment area (1) the demand for suburban living (2) grows. The higher demand makes the relative profitability of greenfield over brownfield (3) in the region higher, which incentivises greenfield development (4) for developers. With more investment going into greenfield areas the perceived attractiveness of suburbs (5) rises which drives demand for suburban living (2) yet higher. Additionally, when the relative profitability of greenfield over brownfield (3) development rises, brownfield/infill redevelopment (6) is disincentivised. Less investments into those areas reduces the perceived attractiveness of urban living (7), driving down the demand for urban living (8). With less demand for urban living (8) the relative profitability of greenfield over brownfield (3) grows yet again, creating a vicious cycle where the popularity of urban living slumps (R4), and the popularity of suburban living grows (R3).
Note 2: The coloured arrows show the relationship between variables. A pink arrow between variables means that they vary in the same direction: an increase in a variable leads to an increase in the variable it points at; a decrease in a variable leads to a decrease in the variable it points at. A blue arrow means that variables vary in the opposite direction: an increase in a variable leads to a decrease in the variable it points at; a decrease in a variable leads to an increase in the variable it points at. Each loop label (e.g. B1) denotes a feedback loop. A feedback loop is either reinforcing (R), or balancing (B). See Box 3.1 and section 3.1 for more information on how to read causal loop diagrams.

Without targeting key factors and dynamics that hinder the profitability and attractiveness of brownfield areas, setting a more stringent target (and enforcing it) is likely unfeasible. Actions that more directly increase the profitability and attractiveness of brownfield development might be more effective. While more in-depth analysis would be needed to understand the systems dynamics underlying the profitability gap between greenfield and brownfield development, Chapter 4 offers some guidance for actions that could change the relative profitability of greenfield compared to brownfield development and thus trigger behavioural change in the direction of brownfield investment. These actions could be accompanied by a more stringent target, which would send a clear message about the direction of change, and if accompanied by measures that effectively address the source of the problem, would also be more feasible.

Efforts to improve public transport and active modes

As noted previously, the CAP (and its emissions reduction targets for the transport sector) include measures for increasing the use of public transport and active modes (Department of the Taoiseach Ireland, 2021[1]). Together with demand management measures for ICEVs (see "Carbon and road pricing" section), increasing the use of sustainable modes (via an additional 500 000 public transport and active journeys per day by 2030) is expected to account for 23% of the GHG emissions savings targeted in the CAP (Department of the Taoiseach Ireland, 2021[1]).

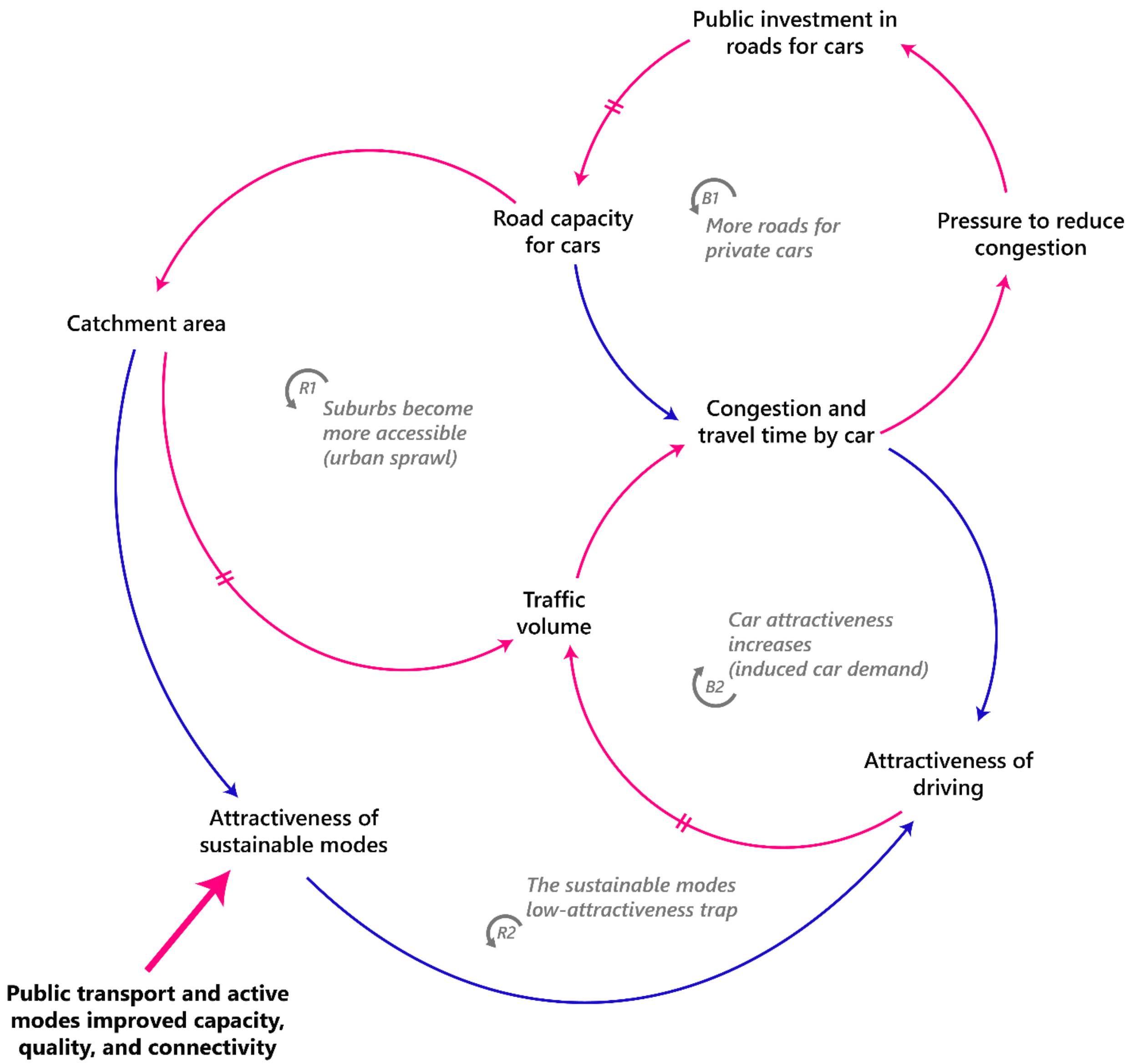
Initiatives to improve public transport and active modes in Ireland include BusConnects (a programme for sustainable transport in the five Irish cities: Dublin, Cork, Galway, Limerick and Waterford), Connecting Ireland (mobility plan for rural areas), public transport infrastructure projects (Metrolink, DART+, Dublin-Cork rail connection), the Safe Routes to School infrastructure programme, and investment in active travel infrastructure and greenways (including the Rural Active Travel Investment Programme and National Cycling Network Plan). Initiatives such as Next Generation Ticketing, new fares as part of BusConnects (e.g. 90-minute fare for buses, commuter rail and Luas in Dublin) and National Journey Planner aim to increase affordability and facilitate public transport use. Actions in the SMP also include the development of pedestrian enhancement plans for the five metropolitan areas, the regional growth centres and key towns; the development and implementation of active travel infrastructure plans for regional growth centres and key towns; and the development of cycling network plans for all counties (Department of Transport, 2022[59]).

The rest of this section presents the detailed results of the assessment for efforts to improve public transport and active modes, based on the framework described in section 3.2.1. The section outlines the intent of the policy type and its transformative potential in terms of the effect on the system feedback loops, physical stocks and mental models underlying car dependency. Based on this analysis, efforts to improve public transport have transformative intent and medium transformative potential (Figure 3.16). It has transformative intent because via infrastructure improvements, more efficient routes and improved quality of services, the various programmes[25] aim to set the conditions for increasing the attractiveness of public transport compared to the car. These efforts have, however, medium transformative potential in the current car-dependent system, as, given the current stocks in the system, they are unlikely to reverse the sustainable transport low-attractiveness trap on their own.

Existing infrastructure limits the potential of efforts to improve public and active transport to reverse the sustainable transport low-attractiveness trap

Figure 3.23 shows that infrastructure improvements, more efficient routes and improved quality of services, can have an effect in weakening the sustainable transport low-attractiveness trap. Nonetheless, after decades of investment privileging cars (see discussion on budget reallocation), infrastructure for active modes and public transport lags behind, while the large road infrastructure dedicated to car use (and still in expansion) continues to widen the attractiveness gap between the car and its alternatives. The low capacity of public transport infrastructure means that increasing its attractiveness will require significant infrastructure development and take time (Caulfield, Carroll and Ahern, 2020[12]).

Figure 3.23. The effect of efforts to improve public transport and active modes on the system dynamics underlying car dependency



Note 1: The behavioural change that improvements in public transport, micro-transit and active modes may trigger depends to a great extent on the attractiveness gap between car driving and other modes. Efforts to improve public transport, micro-transit and active modes can increase the attractiveness of these modes and lessen the sustainable modes low-attractiveness trap (R2). However, on their own, they fail to address induced car demand (B1 and B2) and make these modes more attractive than the car. The attractiveness gap between modes being high in Ireland, this analysis suggests that efforts to lessen the dynamics of induced car demand and urban sprawl are necessary in parallel.
The coloured arrows show the relationship between variables.
Note 2: The coloured arrows show the relationship between variables. A pink arrow between variables means that they vary in the same direction: an increase in a variable leads to an increase in the variable it points at; a decrease in a variable leads to a decrease in the variable it points at. A blue arrow means that variables vary in the opposite direction: an increase in a variable leads to a decrease in the variable it points at; a decrease in a variable leads to an increase in the variable it points at. Each loop label (e.g. B1) denotes a feedback loop. A feedback loop is either reinforcing (R), or balancing (B). See Box 3.1 and section 3.1 for more information on how to read causal loop diagrams.

Combining efforts to improve public and active modes with transformative policies can increase their potential

In parallel to efforts to improve public transport, it would be necessary to prioritise transformative actions such as road space reallocation and the mainstreaming of on-demand services (see below) to close the attractiveness gap. Road space reallocation can reverse induced car demand and set the conditions for rapidly improving the performance of public transport and active modes. At the same time, mainstreaming shared on-demand services would significantly accelerate the development of a network of sustainable alternatives, which would take much longer if reliant solely on public transport and the use of private active modes. This combination of policies can help to close the attractiveness gap more rapidly and effectively, increasing the transformative potential of programmes and investments focused on public and active transport.

Current efforts to improve public transport in Ireland do not explicitly incorporate road reallocation, although many of the major projects have been, in line with this report, integrating this element. The BusConnects programme in Dublin includes good road space reallocation measures (NTA, 2022[67]), potentially becoming exemplary as long as all planned reallocations are realised and private car use is further disincentivised (e.g. through more extensive reallocation of space across the city, reduced parking, pricing measures). The Rural Active Travel programme reallocates space for active modes, but only on a small scale. The Safe Routes to School aims to create safer space for active modes, but it is unclear whether this will be done by reallocating space away from cars. In addition, presumably, the different plans for the development and enhancement of active travel infrastructure mentioned above (e.g. pedestrian enhancement plans, active travel plans) will also include and be part of a major effort for the reallocation of road space (although this is not made explicit). The SMP also includes actions to update standards and revisit legislation to support road space reallocation, and engages both housing and transport authorities to further develop and ensure implementation of the Design Manual for Urban Roads (DMURS). All of these efforts (which can be complemented with recommendations set out in chapter 4 to mainstream road space reallocation) could significantly boost the effects of the impressive efforts that the country is making to bridge the gap in active and public transport infrastructure and services.

Carbon and road pricing

Across OECD countries, fuel excise taxes are a commonly used instrument that effectively results in carbon prices (OECD, 2019[68]). Fuel excise taxes are considered to be the most efficient policy instrument for promoting behavioural change to lower carbon emissions via reduced driving, a shift towards fuel-efficient vehicles and the use of more sustainable transport modes (van Dender, 2019[69]). Road pricing schemes are schemes for charging for road use, such as toll roads, parking taxes (Small and Gomez-Ilbanez, 1998[70]), or congestion charging.

Carbon pricing, along with measures that include some of the EV incentives discussed in 2.2.1, forms one of the cross-cutting policies put forward by the Climate Action Plan (Department of the Taoiseach Ireland, 2021[1]). A carbon tax applying to heating fuels and transport was introduced in Ireland in 2010, and legislation to increase it annually until 2030 is in place. According to the CAP, the implementation of successive increases to the carbon tax is key to reaching the 2030 target, although there is no indication of the expected emissions reductions (Department of the Taoiseach Ireland, 2021[1]). Between 2021 and 2030, Ireland expects to receive an additional 9.5 billion euros from increases in carbon taxes.[26] The Irish authorities have planned for this revenue stream to be dedicated to fund specific actions linked to climate action and the just transition. Around half of this revenue will be allocated to a socially progressive national retrofitting programme for buildings, one third to targeted social welfare and other initiatives to prevent fuel poverty, and the remainder to incentives for green farming practices (Department of Public Expenditure and Reform, 2022[71]).

Road pricing is part of the travel demand management measures considered to help the country achieve its target of -10% ICEVs kilometres by 2030[27] (Department of the Taoiseach Ireland, 2021[1]). Travel demand management measures, coupled with more public transport journeys, would cover 23% of the GHG emissions reductions included in the CAP (Department of the Taoiseach Ireland, 2021[1]). As part of the Regional Assemblies, working groups were established in three regions to discuss the role of transport demand management, including road pricing (along with low-emission zones[28]). According to interviews (Department of Transport, 2022[48]), discussions in these working groups (set up by the Regional Assemblies) have informed decisions on further measures needed to close the estimated gap between planned policies and the GHG reduction target (see Chapter 4 for more).

The rest of this section presents the detailed results of the assessment for carbon and road pricing, based on the framework described in section 3.2.1. The section outlines the intent of the policy type and its transformative potential in terms of the effect on the system feedback loops, physical stocks and mental models underlying car dependency. Based on this analysis, carbon and road prices are categorised as having an anticipatory intent, as both policies anticipate, and aim to contain the growth of car use by increasing the cost of driving.[29] In addition, analysis of their effects on the system's feedback loops, physical stocks, as well as on mental models (discussed in detail in the next subsections), concludes that they have a low to medium transformative potential in the current car-dependent system (Figure 3.16).

As already explained, policies with low or medium transformative potential, such as carbon and road pricing, are still needed in policy packages. They do not have a large power to change the structure of the car-dependent system and "flip" the basin of attraction (see Box 3.2), but they can accelerate the transition once policies with higher transformational capacity are put in place. Moreover, when combined with policies with high transformative potential (e.g. road reallocation; see section 3.2.2.6), pricing signals can increase the speed of change (and may also become more feasible as alternatives to driving become more available).

The revenue from carbon and road prices, when earmarked to develop sustainable modes, can also increase the political support of pricing schemes (ITF-OECD, 2017[72]), and facilitate the development of these modes (e.g. by allowing for multi-annual budgeting, unusual in Irish policy). Experience from British Columbia, Sweden and France has shown that using revenues from carbon taxes to correct inequities as well as build trust in the state, may help increase public acceptance (Douenne and Fabre, 2020[73]; Murray and Rivers, 2015[74]).

Carbon pricing weakens induced demand but the effect is limited and may be reduced in the long-term

Increasing the cost of driving (via increasing fuel costs[30]) can reduce its attractiveness and weaken the dynamic of induced car demand (see Figure 3.25 below). Transforming the car-dependent system would require, however, reversing rather than only weakening unsustainable dynamics. In addition, the effect that carbon pricing can have in weakening induced demand is limited, especially in the long run, for at least three reasons.

Firstly, the impact of carbon pricing on reducing car use is limited by the fact that prices do not affect all cars equally. While drivers of the most inefficient cars can be largely discouraged from driving, the impact will be less for more efficient and electric vehicles (as the cost of driving increases less, or not at all, for these vehicles[31]). Secondly, while carbon prices can steer and accelerate the purchase of fuel-efficient or electric vehicles (Leard, Linn and Cleary, 2020[75]), the emission reductions gained via fuel efficiency improvements may be off-set in the long run by the rebound effect (Dimitropoulos, Oueslati and Sintek, 2016[76]). On the one hand, pricing can help mitigate rebound effects from technological improvements (Dimitropoulos, Oueslati and Sintek, 2016[76]). Nonetheless, they can also increase the incentives for vehicle fleet renewal and accelerate it (Leard, Linn and Cleary, 2020[75]). Thus, similarly to the outcome of EV incentives, the increased efficiency of vehicles (as the fleet is renewed) reduces their use cost and may incentivise people to drive more in the future[32] (Dimitropoulos, Oueslati and Sintek, 2016[76]). This phenomenon has been observed in Ireland, where increasing car travel (and larger vehicles) has counteracted emissions reductions gained via fuel efficiency improvements (SEAI, 2022[77]).

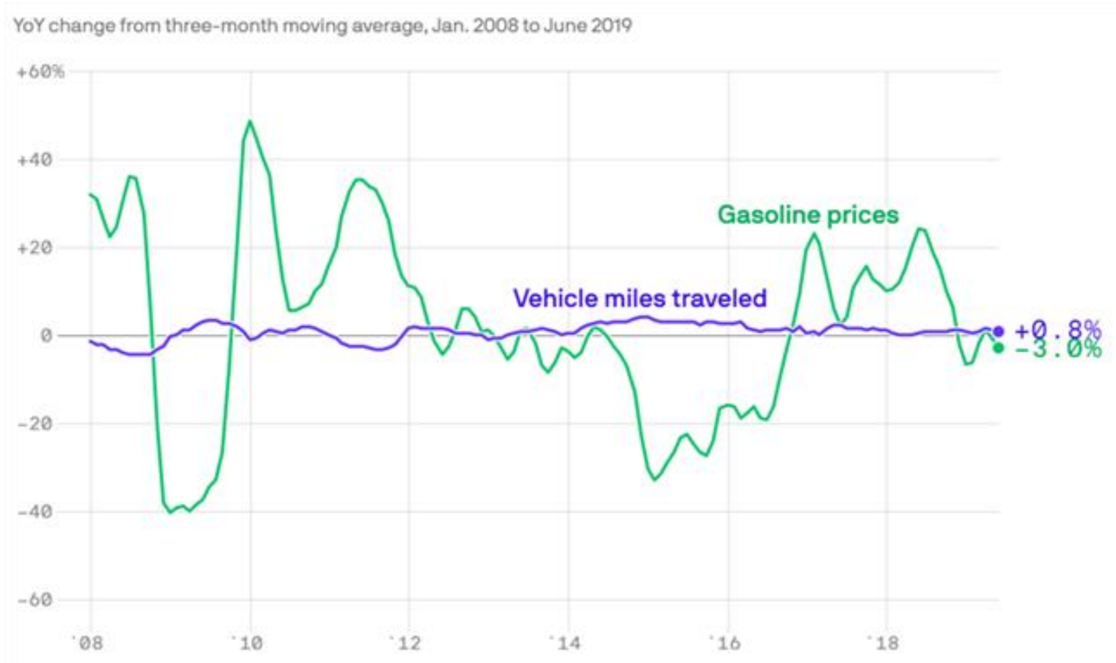
Thirdly, within car-dependent systems, carbon pricing is more likely to contribute to increasing the efficiency of the vehicle stock, while its effect on modal shift remains limited. While in principle, carbon pricing could incentivise modal shifts towards sustainable transport modes, in systems in which alternatives to car driving are not available or convenient, this effect is also limited. Evidence suggests that the impact of fuel prices on driving is low when alternatives to car driving are not available or limited (Geman, 2019[78]), as illustrated in Figure 3.24. Gillingham and Munk-Nielsen (2019[79]) observe that where access to public transport is limited (e.g. in much of the United States), the price elasticity of driving is low, since there is no easy way to shift away from car use. Mattioli, Wadud and Lucas (2018[80]) also find that, in the United Kingdom, low-income households with car-related economic stress (where transport represents a large share of the budget) show the lowest price elasticity in the face of fuel price increases, likely due to a lack of alternatives.[33] Avner, Rentschler and Hallegatte (2014[81]) estimate that the price elasticity of private car travel is twice as high in the presence of a dense public transport network in Paris, than in alternative scenarios where this would not be the case. Similarly, Gillingham and Munk-Nielsen (2019[79]) find that in Denmark, the price elasticity of driving is higher among people who live centrally in urban areas and have the shortest commutes.

The lack of alternative modes in car-dependent systems also limits the political feasibility of introducing high and increasing carbon pricing in Ireland. As mentioned above, changing pricing, on its own, does not change the fact that the Irish transport system (as many transport systems across the globe) fosters – by its design - car use and dependence.

In a number of countries, public resistance has led to policy roll-back or stagnation (Douenne and Fabre, 2020[82]); and almost 40% of emissions in road transport in 44 OECD and G20 countries are priced below estimates of the carbon price that would be needed by 2030 to decarbonise the economy by mid-century (OECD, 2021[83]). Ireland has experienced protests against carbon pricing and the resulting higher fuel prices. For example, in April 2022, The People of Ireland against Fuel Prices protested against the carbon price increase introduced on the 1st of May (The Irish Times, 2022[84]). The lack of alternatives to car driving also affects the political feasibility of road pricing (discussed just below), making it a policy with limited implementation worldwide (ITF-OECD, 2017[72]).

The political feasibility of carbon and road pricing can increase if coupled with policies that improve the attractiveness and availability of alternatives to cars.

Figure 3.24. Gasoline prices and vehicle miles travelled in the United States

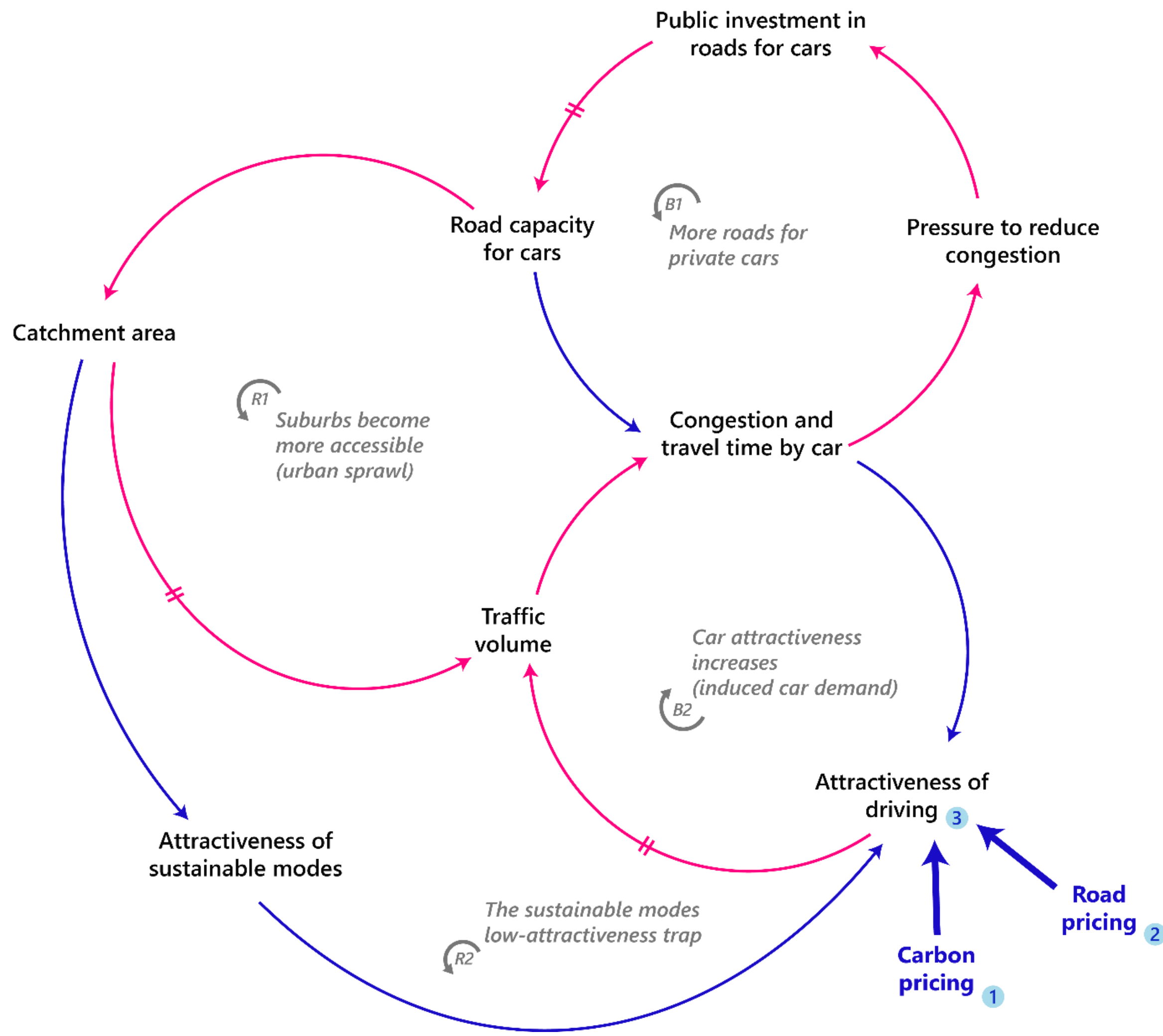


Note: YoY = Year on year.
Source: (Geman, 2019[78]), www.axios.com/carbon-pricing-difficult-to-reduce-transportation-emissions-b6cf8a74-6cfe-47ca-9f6e-c5b4d266d96c.html

Road pricing has a stronger effect on weakening induced demand but this is still not enough to reverse it

Like carbon pricing, road pricing reduces the attractiveness of driving a car by increasing its cost and weakens, in this way, induced demand (see Figure 3.25). Since people must pay the charge regardless of the type of vehicle they drive, the reduced traffic volume incentivised by road pricing is not offset by the rebound effect described above. The effect on induced demand is also larger than the one that carbon pricing can produce, as disincentives for driving affect all car users unless exceptions are granted (e.g. to EVs). Nevertheless, on its own, road pricing doesn't radically change the structure of the car-dependent system: it does not reverse induced demand nor car-dependency. For this reason, while improvements (e.g. more efficient use of road capacity-and thus lower congestion) can be expected from its implementation, it cannot be expected to result in radically different equilibriums (e.g. radically different modal shares or significant reductions in car use). To an important extent, this is due to the fact that road pricing does not address the problem of the over-dimensioned car-purposed capacity that characterises, and is at the centre, of car-dependent systems (see more discussion in the next subsection).

Figure 3.25. The effect of carbon and road prices on the system dynamics underlying car dependency



Note 1: Carbon pricing (1) and road pricing (2) can reduce the attractiveness of driving (3) by increasing its cost. However, when implemented in car-dependent systems, their impact is limited by the lack of alternatives to cars.
Note 2: The coloured arrows show the relationship between variables. A pink arrow between variables means that they vary in the same direction: an increase in a variable leads to an increase in the variable it points at; a decrease in a variable leads to a decrease in the variable it points at. A blue arrow means that variables vary in the opposite direction: an increase in a variable leads to a decrease in the variable it points at; a decrease in a variable leads to an increase in the variable it points at. Each loop label (e.g. B1) denotes a feedback loop. A feedback loop is either reinforcing (R), or balancing (B). See Box 3.1 and section 3.1 for more information on how to read causal loop diagrams.

Carbon and road pricing do not reduce an over-dimensioned stock of car-purposed road capacity

By slowing down induced demand, both carbon and road pricing can reduce the extent and speed at which new road infrastructure capacity is added to the system and traffic volume is increased. In this way, they may lead to lower traffic volumes compared to those that would result from having the same infrastructure in place without introducing pricing. The effect of road pricing can be expected to be higher: making the use of roads more efficient rather than focusing on building more infrastructure is a central goal of road pricing; while this is not the case for carbon pricing.

Nonetheless, transforming car-dependent systems, which have already developed a large road capacity (as in Ireland), requires more than slowing down (or even stopping) car-centred road capacity development. As much as road pricing can make more efficient the use of existing roads, a large capacity of road space is likely to result in a high amount of overall traffic volumes, as an efficient use can be achieved while coping with a large number of vehicles. As pointed out in (OECD, 2021[10]), introducing road pricing without revisiting the over dimensioned road space supply allocated for driving and parking in car-dependent systems (and without investing in public and active modes) may result in reduced congestion, but is still likely to result in high traffic volumes and emissions. The case of London is a good example of the way in which combining road pricing with road space reallocation (see discussion on this policy below) is a better strategy to reduce car use and promote changes in modal shares (ITF-OECD, 2017[72]).

Ireland is still in the phase of planning the introduction of road pricing, but the limited effect of carbon pricing on traffic levels has already been seen in the past: substantial increases in petrol and diesel prices (12% and 17% respectively) in 2017 and 2019 stabilised car use per capita in 2017, and reduced it by 2% in 2018.34 In other words, a large change in prices led to a small change in behaviour, the opposite of what would be expected when pushing on a high leverage point (see section 3.1).

Carbon and road pricing may reinforce the perception of climate action being unjust

In terms of mental models, when implemented on their own in car-dependent systems, carbon and road prices may reinforce the perception that climate action is unjust, reducing the political support for such actions (see Figure 3.24). People who can afford to purchase a more efficient (or electric) car will likely do so and eventually drive more often than before (as explained above), offsetting some, if not all, of the environmental benefits of technological efficiency gain (IPCC, 2014[85]). Those who cannot afford a more efficient car, often low-income households living on the periphery and thus with the least access to alternatives, will be negatively impacted by the price increase. They may, for example, be constrained to spend a higher share of their budget on transport to the detriment of other expenses such as leisure or healthy food (Font Vivanco et al., 2014[86]), especially if connections by alternative transport modes are poor where they live. In Dublin, for example, the public transport network covers only 23% of the commuting zone (ITF, 2019[87]). Poor access by both public transport and active modes is reflected in ITF indicators on accessibility (ITF, 2019[87]): for example, while people in the inner city can find on average 36 shops within 15 minutes by public transport and 18 within 15 minutes on foot, those living in the commuting zone can only reach 12 shops by public transport and 5 on foot in the same time period (ITF, 2022[58]). The Gilets Jaunes movement in France was at least partly a reaction to the consequences of unequal access to good alternatives to cars.

Road space reallocation and street redesign

Road space reallocation and street redesign (road space reallocation hereafter) refers to the rebalancing of road and street space from cars to different transport modes and functions beyond transport (e.g. recreation, bus lanes, markets)[35]. Road space reallocation is one of the demand management measures being considered to meet the target of a 10% reduction in ICEV kilometres by 2030 in the Climate Action Plan (Department of the Taoiseach Ireland, 2021[1]). Together with an increase in sustainable travel, demand management measures are expected to produce approximately 23% of the CAP's emissions reduction target for the transport sector.

While some road space reallocation projects already exist, they are at the pilot stage and would need to be scaled up to unleash their transformative potential. As mentioned before, the 5-year plan of the new SMP includes actions in this direction that may help revert this situation (in particular if complemented with the recommendations in Chapter 4).

The rest of this section presents the detailed results of the assessment for road space reallocation, based on the framework described in section 3.2.1. The section outlines the intent of the policy type and its transformative potential in terms of the effect on the system feedback loops, physical stocks and mental models underlying car dependency. Based on this analysis, road space reallocation is categorised as a policy with a transformative intent and a high potential to transform the current car-dependent system (Figure 3.16). Road space reallocation is designed on the understanding that traffic volume, rather than congestion, is the problem. It aims to transform the system by creating the conditions for shared transport and active modes to become the most attractive. By doing so, the policy intends to trigger behavioural change and lead to disappearing traffic (Box 3.4). As discussed in detail in the below subsections, the policy can transform the current car-dependent system in various ways. First, it breaks an important link in the car-dependent system. Secondly, it reduces a key stock (car-purposed road capacity) that (as discussed in section 3.1) is at the source of car dependency. Thirdly, it creates a new stock of liberated space that can be used for shared transport and active modes to become the most attractive modes, and for places of interest to be reallocated; thus facilitating proximity. This new stock gives rise to different (and more virtuous) loops in the system that replace those of the car-dependent system.

Box 3.4. Evidence on disappearing traffic

As discussed in (OECD, 2021[10]) one of the main barriers that can impede implementing and expanding road space reallocation away from car use is the claim that traffic is displaced, rather than disappearing. Evidence on disappearing traffic has been documented for several years now. After examining over 70 case studies of road space reallocation in 11 different countries, Cairns, Atkins and Goodwin (2002) concluded that, given the right conditions, road space reallocation can result in significant reductions in traffic: on average, the case studies examined resulted in a 21.9% traffic reduction, while in half of the cases, at least a 10.6% drop in car traffic was found. The authors find that the claim that road space reallocation is associated with “traffic problems” is “unnecessarily alarmist”.

More recent studies, dedicated to looking into the impacts of road space reallocation, e.g. across European cities, have concluded that, while there might be a period of adjustment, there is indeed a phenomenon of “disappearing” or “evaporated” traffic (EC, 2009[88]).

This is in line with evidence on recent interventions in Oslo and Copenhagen discussed in (ITF, 2021[89]). In the case of Oslo, interventions reducing road capacity for car use on three main roads resulted in a reduction of car use for commuting of between 16% and 21% without severe consequences in terms of delays or congestion. In Copenhagen, traffic was also reduced after space was designated to increase space dedicated to walking, cycling and public transport (ITF, 2021[89]).

As pointed out by (Cairns, Atkins and Goodwin, 2002[90]), creating the right conditions for road space reallocation is nonetheless key. Among the elements for creating such conditions, they point out careful design and monitoring, as well as communication and consultation. The authors find that the way schemes are perceived by the public and reported in the media is particularly important. The role of communication strategies and the potential synergies with road space reallocation are also emphasised later in this chapter, while Chapter 4 provides recommendations for Ireland in terms of scaling up road space reallocation as well as developing an effective communication strategy to facilitate change.

Source: (EC, 2009[88]).; (ITF, 2021[89]). (Cairns, Atkins and Goodwin, 2002[90]), (OECD, 2021[10])

Road space reallocation “breaks” a link in the car-dependent system and leads to a new system structure

Road space reallocation has the potential to “break” a key link in the car-dependent system (see top, right-hand side of Figure 3.26). As explained in section 3.1, for decades, transport policies have responded to the pressure to reduce congestion with public investments in roads for cars (1 in Figure 3.26), increasing the road capacity for cars (2), which has led to the opposite result: congestion has increased. If instead of trying to reduce congestion by increasing public investment in roads for cars (1), policy focused on liberating space (3) for sustainable modes, these could become more attractive (4), and those that most people use for the bulk of their trips. As noted by Caulfield, Carroll and Ahern (2020[12]), "the main problem that is faced in changing transport behaviours to more sustainable modes of transport is that they have to compete with the private car for investment and road space".

The liberated space (3, Figure 3.26) could be used for walking, cycling and public transport infrastructure, enabling safer, faster and more pleasant travel, and thus increasing the attractiveness of sustainable modes (4). The liberated space (3) can also be used for functions other than transport, such as public seating, green spaces, markets, restaurant terraces or playgrounds. This can increase the attractiveness of inner-city areas, potentially reducing urban sprawl over time and leading to smaller catchment areas (5), in line with the "15-minute city" idea. Pontevedra in Spain is a good example of the effect that liberated space can have on the quality of life in inner cities. A public official in Pontevedra reports that they were able to "stop urban sprawl" and that "to encourage people to return to live in the city, it was necessary to improve the quality of life, reduce traffic, and create a human city" (Burgen, 2018[91]).

Note that the system featured in Figure 3.26 has a different structure to the one characterised by the car dependent system and described in section 3.1.

Road space reallocation addresses the over dimensioned stock of car-purposed capacity

From a stock and flow perspective, road space reallocation increases the stock of liberated space and reduces the stock of road capacity for cars (see Figure 3.26). This is quite unlike most policies, which focus on flows (road pricing focuses on traffic flows, for instance). Road space reallocation focuses instead on reducing a stock that leads to vicious cycles (car-purposed road capacity) and creating a new one (liberated space) that can lead to virtuous ones.

Road reallocation is also inexpensive and can be quickly implemented technically, since there is often no need for a lot of hard infrastructure and its benefits are almost immediate: buses are no longer stuck in traffic (being provided with an exclusive lane) and thus move faster than cars; children ride their bikes to school as cycling becomes safer; seniors ride e-bikes or walk more often as benches are available and walking is pleasant.

Numerous international examples of successful road reallocation projects confirm that road space reallocation is a high leverage point: a small change leads to large changes in the system. The Superblocks in Barcelona (see further discussion in Chapter 4.3) are an iconic example of complete street redesign that, once extended to the entire municipality, will increase the space allocated to pedestrians from 16 to 67% while reducing the space allocated to the road network by 61% (Rueda, 2019[92]). The transformation is low-cost as it does not require hard infrastructure; instead, the use of existing infrastructure is revised. It is estimated that the development of the planned 503 Superblocks (which would cover the entire municipality of Barcelona) will cost 300 million euros. If the 503 Superblocks were implemented over four years, they would cost the City Council 2% of its budget (Rueda, 2020[93]). In Paris, the rue de Rivoli has been gradually closed to private cars after the Covid-19 lockdown and the majority of the street space, signalled with simple markings and traffic signs, was dedicated to two-way cycle traffic (City of Paris, 2022[94]). These four kilometres of cycle lane in the heart of the city serve on average 15 000 cyclists per day (Le Parisien, 2021[95]). Similar small-scale but successful post-Covid-19 projects have taken place in Ireland. For example, a number of stakeholders interviewed expressed their surprise that so many more people now cycle as a response to the temporary bike lanes. This may reflect repressed demand that bursts out as soon as infrastructure becomes available. The reallocation of parking space to a pedestrian area on the Kildare Market Square is another example of public space reallocation. The initiative received positive feedback from citizens and businesses, and local authorities are now looking into expanding the transformed area.

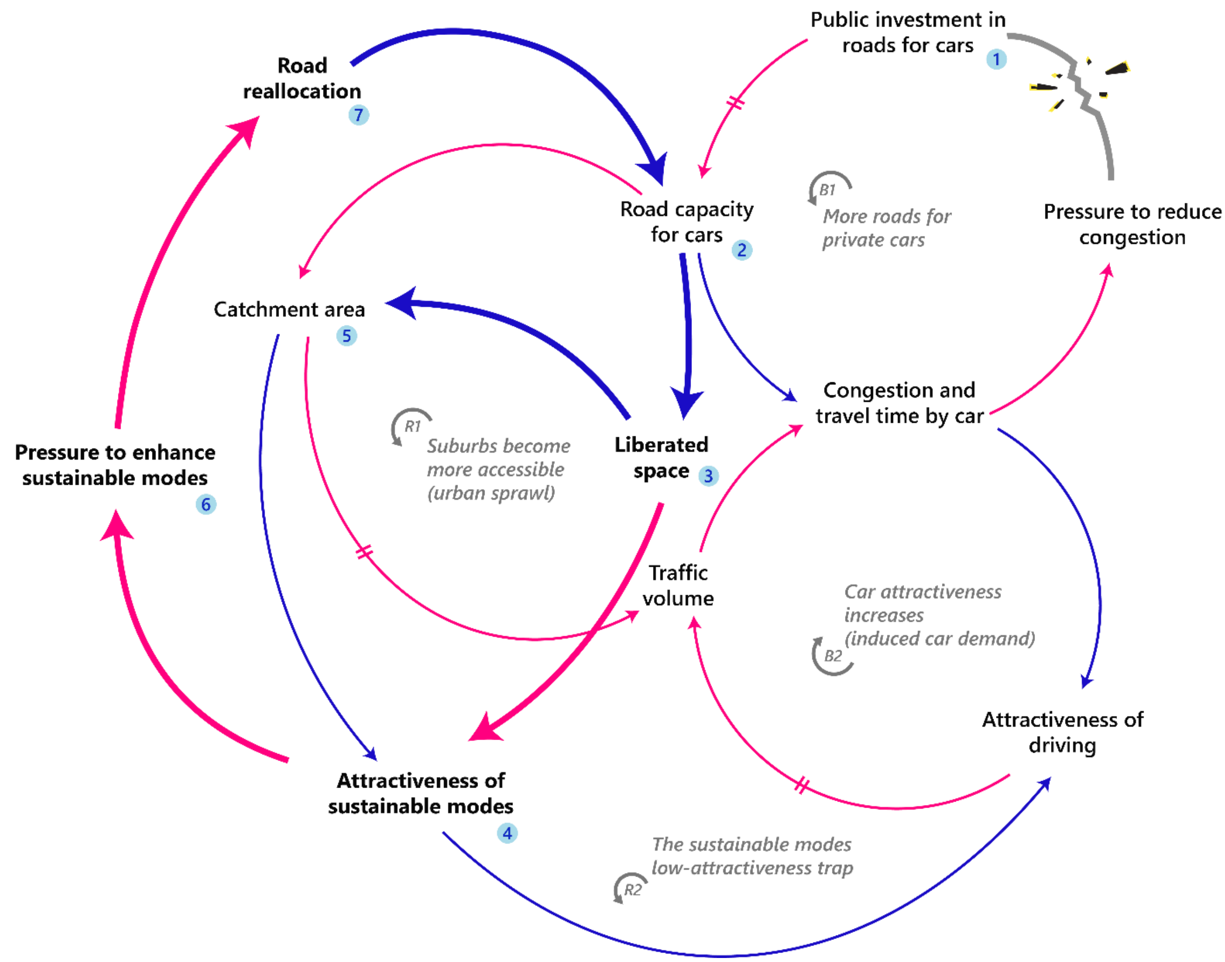
Extending road space reallocation beyond central areas will be necessary to ensure wide impact and avoid inequalities and gentrification. When projects are only implemented in central areas, they can introduce inequality problems, for example, by creating significantly greater benefits for central city dwellers than for commuters from the periphery. Another downside can be gentrification and eviction, since improving conditions in a constrained space can create price differentials between the reconfigured area and other areas (OECD, 2021[10]). Making large-scale changes and combining road space reallocation with the development of public transport and the creation of new shared services, can reduce these problems substantially. On the peripheries, reallocation can make alternative modes (e.g. shared bicycles, electric bicycles, electric cargo bicycles and scooters) viable as a link between residents and (new and existing) transport hubs. This can make commuting to central areas seamless, using only sustainable modes. Many suburbs also have some density of services already; in addition to bringing more services closer to people (using liberated space), road space reallocation can be especially leveraged in suburbs, linking people to services via networks of infrastructure (e.g. cycle lanes) that allow them to travel via sustainable modes.

The space liberated by road space reallocation can also facilitate the spread and uptake of on-demand services such as e-bikes and e-scooters. As discussed below, on-demand services can fill the gaps in connectivity that are sometimes difficult to fill with traditional public transport and can increase the overall functionality of public transport via multi-modal integration. They can also ease, and significantly reduce the cost of, the electrification of the vehicle fleet (see the section on refocusing the electrification strategy in Chapter Four).

Road space reallocation may facilitate a change in mental models

Road space reallocation may also have a positive impact on mental models and political support for policies aiming to transform car-dependent systems. Irish stakeholders have identified a lack of political support as a key barrier to the up-scaling of road space reallocation. However, a study conducted in 2020 showed that “84% of people in the… [Dublin Metropolitan Area] would be in favour of the government investing in segregated cycling infrastructure at the price of road space for other modes of transport” (Caulfield, Carroll and Ahern, 2020[12]). As people experience its well-being benefits (some of which are immediate, see Chapter 4 for a discussion on tactical urbanism), public pressure to enhance sustainable transport modes (6 in Figure 3.26) can increase, facilitating further road space reallocation (7), road capacity for cars (2) reduction, and further liberated space (3) for sustainable modes and other uses. While possible, triggering such a dynamic is not straightforward since sustainable modes need to function properly to ensure positive experiences with them. Investment in communication to showcase the well-being benefits of road space reallocation, such as days without cars, and fostering participatory approaches can accelerate political support for reallocating roads to sustainable modes. As WIRED UK (WIRED UK, 2022[96]) observes, “people hate the idea of car-free cities – until they live in one”.

Figure 3.26. The effect of road space reallocation on the system dynamics underlying car dependency



Note: The coloured arrows show the relationship between variables. A pink arrow between variables means that they vary in the same direction: an increase in a variable leads to an increase in the variable it points at; a decrease in a variable leads to a decrease in the variable it points at. A blue arrow means that variables vary in the opposite direction: an increase in a variable leads to a decrease in the variable it points at; a decrease in a variable leads to an increase in the variable it points at. Each loop label (e.g. B1) denotes a feedback loop. A feedback loop is either reinforcing (R), or balancing (B). See Box 3.1 and section 3.1 for more information on how to read causal loop diagrams.

Mainstreaming on-demand shared services

In the Climate Action Plan, shared on-demand services (e.g. electric bicycles, electric cargo bicycles and, where legalised, e-scooters) are said to have the potential to extend "both the number and length of sustainable trips across Ireland" (Department of the Taoiseach Ireland, 2021[1]). However, their role in meeting the 2030 target of 500 000 additional journeys per day by sustainable modes is unclear.

While often small, initiatives for mainstreaming on-demand services exist in Ireland. Legislation to allow the use of e-scooters on streets and roads is being drafted (Department of Transport, 2022[59]). Bike-sharing schemes are available in the central areas of several cities, such as docked DublinBikes and station less Bleeper in Dublin (Citizen Information, 2022[97]) and docked TFI Bikes in Cork, Galway, Limerick and Waterford (TFI Bikes, 2022[98]). Car-sharing services also exist, though only in Dublin (e.g. GoCar, YUKO) (Movmi, 2019[99]). In rural areas, TFI Local Link offers bookable community transport services that offer door-to-door connections alongside its regular bus service (ITF, 2021[100]). Importantly, the new SMP includes a number of actions in its 5-year plan that are focused on the development of different on-demand shared services. Among these are the expansion of bike (including electric) share schemes in the five major cities; the development of a model for deploying bike share schemes (including the potential for electric bikes) in regional growth centres and key towns; and the expansion of shared car, bike and powered personal transporters (which include micro-mobility) in transport hubs. A number of actions in the SMP also aim at developing supporting infrastructure that is key for these services. For instance, by developing active infrastructure programmes and cycling network plans, as well as secure bike parking. Some of these actions are small in terms of bridging the current infrastructure gap (e.g. the target for developing secure bike parking is to reach 1000 parking spots by 2025 in key towns and cities plus transport hubs). Thus, it could be good to revisit some of the targets in terms of the needs identified once active travel plans and other mentioned documents are developed. In addition, more ambitious modal shift targets (as recommended in this report; see chapter 4) might also require the scaling up of some of these efforts, and thus targets set in the current SMP should also be revisited in the light of this.

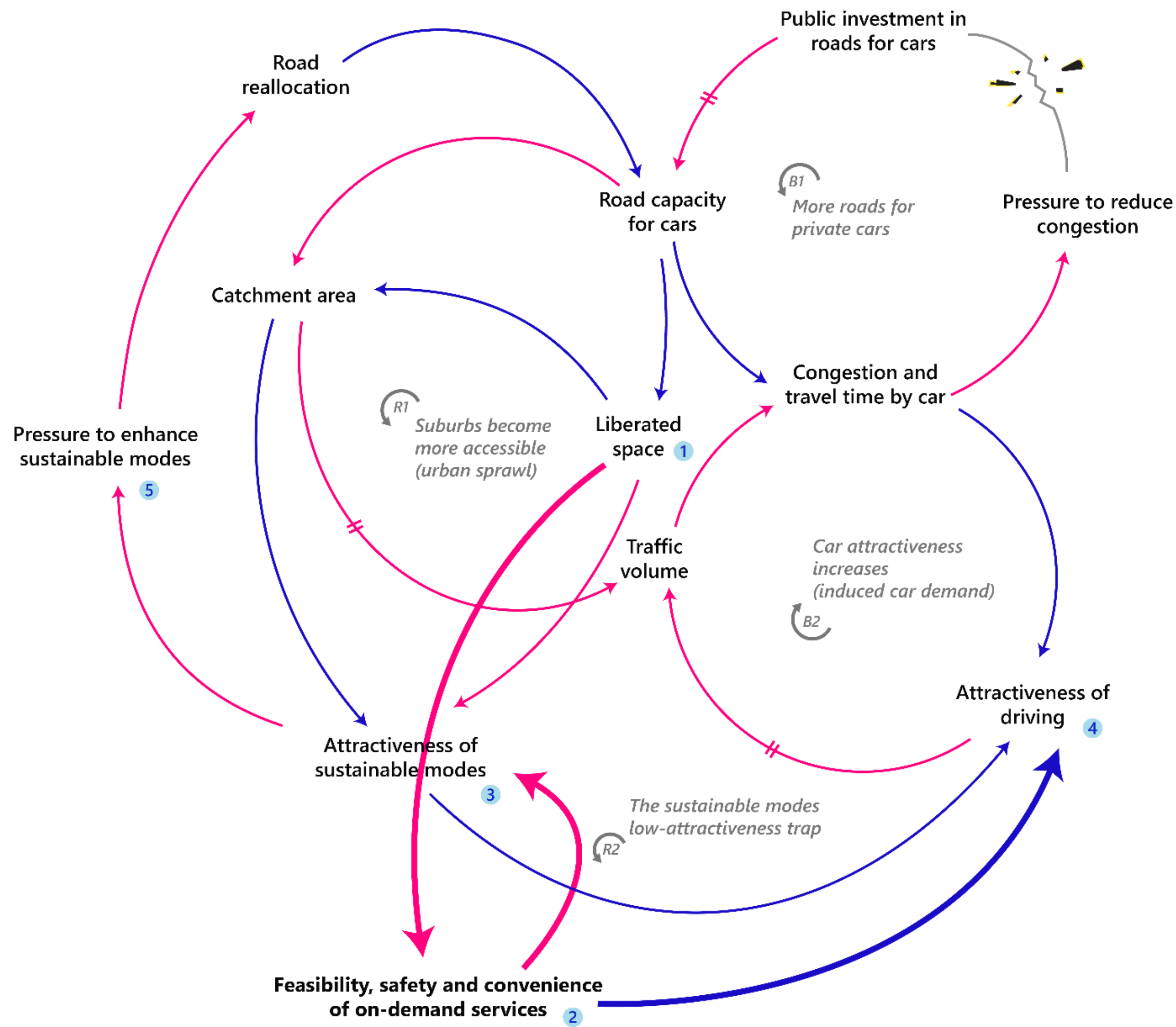
The rest of this section presents the detailed results of the assessment for the mainstream of on-demand shared services, based on the framework described in section 3.2.1. The section outlines the intent of the policy type and its transformative potential in terms of the effect on the system feedback loops, physical stocks and mental models underlying car dependency. Based on this analysis, efforts to mainstream on-demand services have transformative intent and high transformative potential (Figure 3.16). This policy has transformative intent as it aims at narrowing the attractiveness gap between shared transport and cars, and sees on-demand services as a cost- and time-effective way to do so. It has high transformative potential because, by creating connections and introducing new types of service (thus reorganising the system structure), it increases the attractiveness of existing modes (public transport and active modes) while also enlarging the offer of sustainable services. This analysis suggests that, when coupled with road space reallocation, main-streaming on-demand shared services has a high potential to trigger behavioural change through the creation of a network of safe, convenient and accessible alternatives to the car. Rapid acceleration of the development of a multi-modal transport system via on-demand services also has the potential to reduce the vehicle stock and thus facilitate electrification.

Mainstreaming on-demand shared services contribute to changing the structure of the system

In terms of systems dynamics, the mainstreaming of on-demand services (including bicycles, cargo bikes, micro-mobility and ride-sharing) has the potential to transform the transport system into a multi-modal system in which different forms of transport support each other seamlessly (Figure 3.27). While efforts to improve public transport and on-demand shared services complement each other, the mainstreaming of shared on-demand services is considered to have higher transformative potential than efforts to improve public transport: by increasing transport options, on-demand shared services can improve the system's connectivity in a cost-efficient manner and at a faster pace than public transport could do on its own.[36]

Space is an important limitation for the development of shared on-demand services (ITF, 2022[101]). The benefits of new shared mobility services depend greatly on a better allocation of scarce road space (e.g. bus corridors, ride-sharing lanes), which is now mainly allocated to space-consuming modes such as cars. The liberated space (1 in Figure 3.27) made available thanks to road space reallocation can be at least partly allocated to on-demand shared services, can increase their feasibility, safety and convenience (2, in Figure 3.27), and hence their attractiveness[37] (3): when (dedicated) space is available, on-demand shared services can become faster, safer and more pleasant than driving a car, whose attractiveness is reduced (4).

Figure 3.27. The effect of mainstreaming on-demand shared services on the dynamics underlying car dependency



Note: The coloured arrows show the relationship between variables. A pink arrow between variables means that they vary in the same direction: an increase in a variable leads to an increase in the variable it points at; a decrease in a variable leads to a decrease in the variable it points at. A blue arrow means that variables vary in the opposite direction: an increase in a variable leads to a decrease in the variable it points at; a decrease in a variable leads to an increase in the variable it points at. Each loop label (e.g. B1) denotes a feedback loop. A feedback loop is either reinforcing (R), or balancing (B). See Box 3.1 and section 3.1 for more information on how to read causal loop diagrams.

As people experience the benefits of a multi-modal transport network, the public pressure to enhance sustainable modes may increase (5), accelerating the virtuous cycle illustrated in Figure 3.27. This virtuous cycle can be further accelerated if the integration of on-demand services among themselves and with public and active modes is coupled with actions such as:

- Integrated ticketing allowing users to access all transport services with a single account, such as the TFI Go pilot, as the first stage of the Next Generation Ticketing programme.
- Subsidies and/or regulation to ensure on-demand services are available on the peripheries of cities where profitability may be lower, and to ensure that different modes (e.g. cargo bikes) are available.
- GPS technology and integrated apps providing users with real-time information, such as TFI's Real-time Information app (Box 3.5).

- Improvements in public transport infrastructure via initiatives such as BusConnects and Connecting Ireland. Public transport is the backbone of multi-modal networks (OECD, 2021[10]) and efforts in this direction should continue.

Mainstreaming on-demand shared services can reduce the vehicle stock and increase the effectiveness of electrification efforts

With respect to stocks and flows, a properly functioning multi-modal transport system reduces the need for (and dependence on) private cars, potentially reducing the size of the fleet and facilitating electrification. The electrification of a small and shrinking fleet is faster, cheaper and more environmentally friendly than the electrification of a big and growing fleet. Moreover, a system where modes such as micro-mobility (including e-bikes and e-scooters), buses and shared fleets increase their relative importance compared to private cars, will also increase the scope of electrification, as the uptake of electric mobility has been much faster for these vehicles compared to private cars (IPCC, 2022[25]).

Box 3.5. Systems innovation and the untapped potential of technology

The mainstreaming of on-demand services into public transport is an example of the potential of technology to trigger system innovation, that is, innovation focused on improving system functioning rather than just improving vehicles (e.g. by electrification). For example, GPS technologies and apps enable users to locate and combine multiple transport options in real time. They enable a system to be organised in such a way that people can reach their destinations without owning a car (the idea of mobility as a service).

On-demand shared services are also a good example of the complementary relationship between system innovation and business-as-usual innovation (i.e. innovation focused on improving the efficiency of parts of a system). For example, e-bikes (a technological change at the parts level) increase the convenience of cycling and expand its range of use (greater distances and more users), further reducing the need for cars (even shared). In combination with GPS, apps, and so on, e-bike-sharing systems can create a new service, so that not everyone needs to own an e-bike nor even use their own if a shared one is more convenient.

Source: (OECD, 2021[10])

Communication efforts

Ireland is making efforts to communicate the importance of reducing emissions in the transport sector. As part of its Climate Action Plan (Department of the Taoiseach Ireland, 2021[1]), the government has set up the Climate Communications Coordination Committee (CCCC),[38] the National Dialogue on Climate Action (NDCA) and the Zero Emission Vehicles Ireland Office (ZEVI). The CCCC aims to advise departments and agencies on overarching messaging content and support them in their climate communication initiatives (Department of the Taoiseach, 2022[102]). The NDCA was established in 2021 as the forum for engaging, enabling and empowering stakeholders and the public (DECC, 2022[103]). Established in 2022, the ZEVI aims to support “consumers, the public sector and businesses to continue to make the switch to zero emission vehicles” (Office of Zero Emission Vehicles, 2022[104]).

In addition, the new SMP sets out an explicit goal (goal 8) to improve research and engagement with citizens. The strategy also includes specific actions to support this goal by establishing new structures and mechanisms for engagement with the public and other stakeholders. Among these is the development and implementation of a public engagement strategy, which will have as objective to promote the benefits of and raise public awareness of sustainable transport options; and convening a National Sustainable Mobility Forum with the aim of communicating with the public on progress.

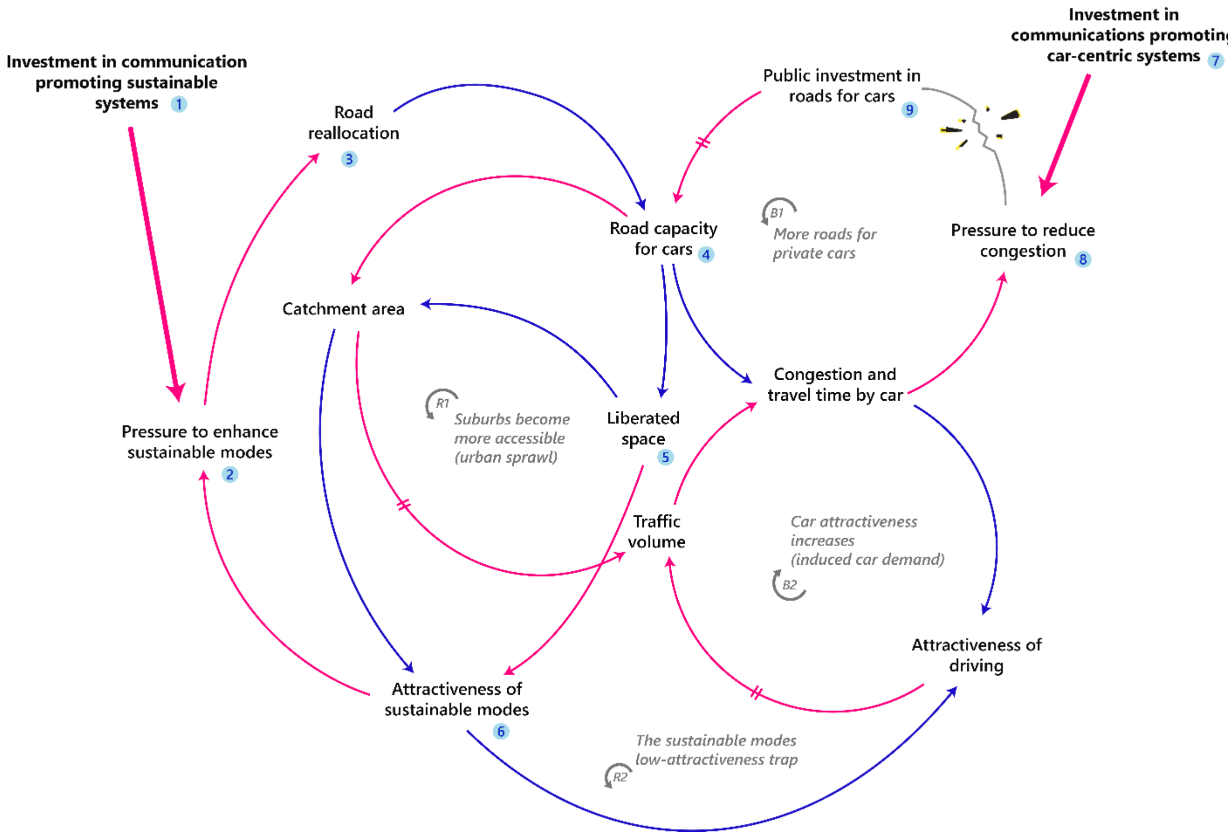
The rest of this section presents the detailed results of the assessment of communication efforts, based on the framework described in section 3.2.1. The section outlines the intent of the policy type and its transformative potential in terms of the effect on the system feedback loops, physical stocks and mental models underlying car dependency. Based on this analysis, this report concludes that when focused on sustainable transport systems, communication efforts have a transformative intent and a high transformative potential (Figure 3.16). Policy packages, including ambitious communication efforts, acknowledge the importance of mindsets in shaping and sustaining systems. By challenging existing mindsets and demonstrating the well-being benefits of sustainable transport systems (as defined in Chapter 2), communication efforts can increase political support for transformative policies, which is key to the transition towards such systems. At the same time, to be effective, communication efforts need to be coupled with policies that enable the conditions for sustainable modes to function properly, so that people can experience their benefits first-hand.

Communication efforts can increase feasibility for implementing other transformative policies

Investment in communication promoting sustainable systems (1 in Figure 3.28) can increase public pressure for public transport and active modes (e.g. by showing the well-being benefits of these systems), thus accelerating a virtuous cycle: as public pressure to enhance sustainable modes (2) increases, road space reallocation (3) becomes more feasible and can be accelerated, decreasing the road capacity for cars (4) and further liberating space (5) for public transport and active modes, increasing the attractiveness of sustainable modes (6) and the pressure to improve them further (2).

The benefits of these efforts and the virtuous cycle they could trigger may, however, be offset by investment in communication promoting car-centric systems (7). These investments reinforce the already present vicious cycle of induced demand (B2) by increasing the pressure to reduce congestion (8). As discussed earlier, road space reallocation “breaks the link” (upper right-hand side of Figure 3.28), between pressure to reduce congestion (8) and public investment in roads for cars (9). Communication promoting car-centric systems (7) can be an important barrier to doing this. Therefore, as discussed in chapter 4, regulating investments in communications promoting car-centric systems (7) may be necessary to increase political support for the transformative policies described in this report.

Figure 3.28. The effect of communication efforts on the systems dynamics underlying car dependency



Note 1: The coloured arrows show the relationship between variables. A pink arrow between variables means that they vary in the same direction: an increase in a variable leads to an increase in the variable it points at; a decrease in a variable leads to a decrease in the variable it points at. A blue arrow means that variables vary in the opposite direction: an increase in a variable leads to a decrease in the variable it points at; a decrease in a variable leads to an increase in the variable it points at. Each loop label (e.g. B1) denotes a feedback loop. A feedback loop is either reinforcing (R), or balancing (B). See Box 3.1 and section 3.1 for more information on how to read causal loop diagrams.
Note 2: The coloured arrows show the relationship between variables. A pink arrow between variables means that they vary in the same direction: an increase in a variable leads to an increase in the variable it points at; a decrease in a variable leads to a decrease in the variable it points at. A blue arrow means that variables vary in the opposite direction: an increase in a variable leads to a decrease in the variable it points at; a decrease in a variable leads to an increase in the variable it points at. Each loop label (e.g. B1) denotes a feedback loop. A feedback loop is either reinforcing (R), or balancing (B). See Box 3.1 and section 3.1 for more information on how to read causal loop diagrams.

Reducing the "stock" of car-centric communication is as important as increasing communication promoting sustainable modes

Investment in communication promoting car-centric systems has been significantly higher than investment in communication promoting sustainable systems. The automobile industry spends between 400 and 600 euros per car sold on advertising (Ali, 2021[105]). With approximately 105 000 cars sold in Ireland in 2021, a rough estimate is that investment in car-centric advertising amounted to approximately 50 million euros for the year. By contrast, the Irish government estimates that spending on communication promoting sustainable transport modes will amount to 6 to 7 million euros in 2022 (Department of Transport, 2022[48]). While information on cumulative investment (stock) was not available, the size of the vehicle fleet can be used to calculate a rough proxy for it: if the estimated amount spent per car is applied to the entire vehicle fleet in Ireland, the stock of investment in advertising would be approximately 1 billion euros.

Furthermore, communication efforts by the Irish government may unintentionally reinforce the mindset promoted by commercial car-centric communication. The Irish Climate Action Plan 2021 expects 67% of emission reductions to come from better vehicles and fuels (Department of the Taoiseach Ireland, 2021[1]), which may reflect an implicit frame around technological optimism[39], which may narrow the conceivable solutions. For example, one of the strategy's goals is to reduce the kilometres travelled by ICEVs rather than the total number of kilometres travelled by car. Also, ZEVI highlights the benefits of switching to EVs (lower driving costs, the convenience of charging at home, driving the latest technology that looks and feels good, polluting less, benefit-in-kind tax exemptions) without mentioning alternatives to private car ownership or the consequences of car use (SEAI, 2022[106]; Office of Zero Emission Vehicles, 2022[104]). Chapter 4 provides initial suggestions for refocusing and scaling up communication efforts.

References

Adams, G. et al. (2021), "People systematically overlook subtractive changes", *Nature 2021 592:7853*, Vol. 592/7853, pp. 258-261, https://doi.org/10.1038/s41586-021-03380-y. [31]

Ahrens, A. and S. Lyons (2019), "Changes in Land Cover and Urban Sprawl in Ireland From a Comparative Perspective Over 1990–2012", *Land 2019, Vol. 8, Page 16*, Vol. 8/1, p. 16, https://doi.org/10.3390/LAND8010016. [19]

Ali, A. (2021), *Tesla's Spending on R&D and Marketing, Compared to Other Automakers*, Visual Capitalist, https://www.visualcapitalist.com/comparing-teslas-spending-on-rd-and-marketing-per-car-to-other-automakers/ (accessed on 1 July 2022). [105]

Archsmith, J., E. Muehlegger and D. Rapson (2021), *Future Paths of Electric Vehicle Adoption in the United States: Predictable Determinants, Obstacles and Opportunities*, National Bureau of Economic Research, Cambridge, MA, https://doi.org/10.3386/w28933. [55]

Aryanpur, V. et al. (2022), *Decarbonisation of passenger light-duty vehicles using spatially resolved TIMES-Ireland Model*, Elsevier. [40]

Avner, P., J. Rentschler and S. Hallegatte (2014), *Carbon Price Efficiency: Lock-in and Path Dependence in Urban Forms and Transport Infrastructure*, The World Bank, https://doi.org/10.1596/1813-9450-6941. [81]

Bauer, G. (2018), *The impact of battery electric vehicles on vehicle purchase and driving behavior in Norway*, Pergamon. [43]

Brand, C. and J. Anable (2019), *'Disruption' and 'continuity' in transport energy systems: the case of the ban on new conventional fossil fuel vehicles*, ECEEE 2019 Summer Study, Hyères France, https://eprints.whiterose.ac.uk/147678/ (accessed on 27 June 2022). [44]

Burgen, S. (2018), ""For me, this is paradise": Life in the Spanish city that banned cars", *The Guardian*, https://www.theguardian.com/cities/2018/sep/18/paradise-life-spanish-city-banned-cars-pontevedra (accessed on 20 July 2021). [91]

Cairns, S., S. Atkins and P. Goodwin (2002), "Disappearing traffic? The story so far", *Municipal Engineer*, Vol. 151/1, pp. 13-22, https://doi.org/10.1680/muen.151.1.13.38856. [90]

Cambridge Dictionary (2022), *Curtilage Definition*, Cambridge Dictionary. [109]

Cambridge Dictionary (2022), *Definition of catchment area*, https://dictionary.cambridge.org/dictionary/english/catchment-area (accessed on 9 August 2022). [18]

Carroll, P. and P. O'Sullivan (2020), *Forecasting the impact of the Planning, Land Use and Transport Outlook (PLUTO) Project – a 2040 Ireland case study*, Elsevier B.V., https://doi.org/10.1016/j.trpro.2020.09.007. [20]

Caulfield, B., P. Carroll and A. Ahern (2020), *Transitioning to low carbon and sustainable mobility*, Climate Change Advisory Council, http://hdl.handle.net/2262/93659 (accessed on 26 July 2022). [12]

Caulfield, B. et al. (2022), "Measuring the equity impacts of government subsidies for electric vehicles", *Energy*, Vol. 248, p. 123588, http://doi.org/10.1016/j.energy.2022.123588. [41]

Central Bank of Ireland (2019), *Population Change and Housing Demand in Ireland*. [21]

Citizen Information (2022), *Cycling in Ireland*, Citizen Information - Travel and Recreation - Cycling, https://www.citizensinformation.ie/en/travel_and_recreation/cycling/overview_cycling.html#lc562c (accessed on 24 June 2022). [97]

City of Paris (2022), *Toute la rue de Rivoli réservée aux piétons et aux*, https://www.paris.fr/pages/la-rue-de-rivoli-reservee-aux-pietons-et-aux-velos-7792 (accessed on 28 June 2022). [94]

Conway, R. et al. (2019), "The Current State of Cycling Infrastructure in Dublin and Copenhagen; A Comparison of Cycling Infrastructure in 8 Radial Routes into the City Centre of Dublin and Copenhagen", *Irish Medical Journal*, https://imj.ie/the-current-state-of-cycling-infrastructure-in-dublin-and-copenhagen-a-comparison-of-cycling-infrastructure-in-8-radial-routes-into-the-city-centre-of-dublin-and-copenhagen/ (accessed on 12 July 2022). [23]

CSO (2019), *National Travel Survey 2019*, Central Statistics Office (CSO), Cork, Ireland, https://www.cso.ie/en/releasesandpublications/ep/p-nts/nationaltravelsurvey2019/ (accessed on 23 August 2022). [24]

CSO (2016), *Occupied Dwellings*, Census of Population 2016 - Profile 1 Housing in Ireland, https://www.cso.ie/en/releasesandpublications/ep/p-cp1hii/cp1hii/od/ (accessed on 12 July 2022). [60]

CSO Ireland (2022), *Mechanically Propelled Vehicles under Current Licence*, http://Mechanically Propelled Vehicles under Current Licence (accessed on 23 September 2022). [14]

DECC (2022), *National Dialogue on Climate Action (NDCA)*, https://www.gov.ie/en/publication/4bf2c-national-dialogue-on-climate-action-ndca/ (accessed on 25 July 2022). [103]

Department of Public Expenditure and Reform (2022), *Budget 2022 The Use of Carbon Tax Funds 2022*. [71]

Department of the Taoiseach (2022), *Appendix 1 Climate Action Plan 2021 Progress Report*, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjHsO6UjpT5AhX8g84BHVoHCwAQFnoECAMQAQ&url=https%3A%2F%2Fassets.gov.ie%2F226640%2F455e596a-42c5-4d64-b261-21e63e7ccd49.pdf&usg=AOvVaw2oqVNH-GJGDmF766sD9Km7. [102]

Department of the Taoiseach Ireland (2021), *Climate Action Plan 2021*, https://www.gov.ie/en/campaigns/2f87c-climate-action-plan-2021/# (accessed on 14 June 2022). [1]

Department of Transport (2022), "Interviews with the Climate Engagement & Governance Division, Department of Transport". [48]

Department of Transport (2022), *National Sustainable Mobility Policy*, https://www.gov.ie/en/publication/848df-national-sustainable-mobility-policy/ (accessed on 13 June 2022). [59]

Department of Transport (2021), *Electric Vehicle Policy Pathway*, gov.ie, https://www.gov.ie/en/publication/e62e0-electric-vehicle-policy-pathway/. [50]

Department of Transport (2021), *Revised National Development Plan will transform how we travel, with a 35 billion euro package prioritising investment in sustainable, active, accessible public transport*, https://www.gov.ie/en/press-release/35dfe-revised-national-development-plan-will-transform-how-we-travel-with-a-35-billion-euro-package-prioritising-investment-in-sustainable-active-accessible-public-transport/ (accessed on 27 June 2022). [56]

Department of Transport Ireland (2022), *The benefits of switching to an Electric Vehicle*, https://www.gov.ie/en/publication/fabfa-electric-vehicles/ (accessed on 10 June 2022). [34]

Department of Transport Ireland (2020), *Sustainable Mobility Policy Review - Background Paper 4 Congestion*. [8]

Dept of Rural and Community Development and Dept of Housing Local Government and Heritage (2022), *Town Centre First Policy*, https://www.gov.ie/en/publication/473d3-town-centre-first-policy/ (accessed on 13 June 2022). [62]

Dimitropoulos, A., W. Oueslati and C. Sintek (2016), "The Rebound Effect in Road Transport: A Meta-analysis of Empirical Studies", No. 113, OECD, Paris. [76]

Douenne, T. and A. Fabre (2020), *Yellow Vests, Carbon Tax Aversion, and Biased Beliefs*, Paris School of Economics, Paris, https://www.parisschoolofeconomics.eu/docs/douenne-thomas/job-market-paper--yellow-vests,-carbon-tax-aversion,-and-biased-beliefs.pdf (accessed on 27 June 2022). [82]

Douenne, T. and A. Fabre (2020), "French attitudes on climate change, carbon taxation and other climate policies", *Ecological Economics*, Vol. 169, p. 106496, https://doi.org/10.1016/J.ECOLECON.2019.106496. [73]

Dowling, K. (2022), *Over 8% of cars sold in 2021 were battery electric*, IEVOA. [45]

Dún Laoghaire-Rathdown County Council (2019), *Ballyogan & Environs: Local Area Plan 2019 - 2025*, https://www.dlrcoco.ie/sites/default/files/atoms/files/ballyogan_and_environs_local_area_plan_2019-2025.pdf (accessed on 27 June 2022). [108]

EC (2009), *Directorate-General for the Environment Reclaiming city streets for people Chaos or quality of life?*. [88]

Environmental Protection Agency Ireland (2022), *Environmental Protection Agency - Transport*, https://www.epa.ie/our-services/monitoring--assessment/climate-change/ghg/transport/ (accessed on 10 June 2022). [2]

Eurostat (2022), *Database - Population and demography*, https://ec.europa.eu/eurostat/web/population-demography/demography-population-stock-balance/database (accessed on 10 June 2022). [15]

Eurostat (2022), *Passenger Cars in the EU*, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Passenger_cars_in_the_EU#An_almost_10_.25_increase_in_EU-registered_passenger_cars_since_2015 (accessed on 26 September 2022). [13]

Font Vivanco, D. et al. (2014), "The Remarkable Environmental Rebound Effect of Electric Cars: A Microeconomic Approach", https://doi.org/10.1021/es5038063. [86]

Gaur, A. et al. (2022), "Low energy demand scenario for feasible deep decarbonisation: Whole energy systems modelling for Ireland", *Renewable and Sustainable Energy Transition*, Vol. 2, p. 100024, https://doi.org/10.1016/J.RSET.2022.100024. [38]

Geman, B. (2019), *Transportation emissions are a tough nut to crack*, Axios, https://www.axios.com/carbon-pricing-difficult-to-reduce-transportation-emissions-b6cf8a74-6cfe-47ca-9f6e-c5b4d266d96c.html (accessed on 30 August 2021). [78]

Gillingham, K. and A. Munk-Nielsen (2019), "A Tale Of two tails: Commuting and the fuel price response in driving", *Journal of Urban Economics*, Vol. 109, pp. 27-40, https://doi.org/10.1016/J.JUE.2018.09.007. [79]

Government of Ireland (2022), *Town Centre First: A Policy Approach for Irish Towns*, Department of Rural and Community Development; Department of Housing, Local Government and Heritage. [65]

Government of Ireland (2018), *Project Ireland 2040: National Planning Framework*, https://assets.gov.ie/7338/31f2c0e4ba744fd290206ac0da35f747.pdf (accessed on 27 June 2022). [61]

IEA (2022), *Global EV Outlook 2022 – Analysis - IEA*, https://www.iea.org/reports/global-ev-outlook-2022 (accessed on 24 June 2022). [51]

Industry, Society of the Irish Motor (2022), *222 Registration Begins: New car registrations marginally ahead first half of the year | SIMI*, https://www.simi.ie/en/news/222-registrations-begins-new-car-registrations-marginally-ahead-first-half-of-the-year (accessed on 20 September 2022). [46]

IPCC (2022), "Climate Change 2022: Mitigation of Climate Change. Summary for Policymakers", http://www.ipcc.ch (accessed on 13 June 2022). [25]

IPCC (2014), *Transport. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, https://www.ipcc.ch/report/ar5/wg3/transport/. [85]

ITF (2022), *How accessible is your city?*, https://www.itf-oecd.org/urban-access-framework (accessed on 21 June 2022). [58]

ITF (2022), "Streets That Fit: Re-allocating Space for Better Cities", *International Transport Forum Policy Papers*, No. 100, OECD Publishing, Paris, https://doi.org/10.1787/5593d3e2-en. [101]

ITF (2021), "Innovations for Better Rural Mobility", *ITF Research Reports*, OECD Publishing, Paris, https://www.itf-oecd.org/innovations-better-rural-mobility (accessed on 24 June 2022). [100]

ITF (2021), *Reversing Car Dependency | ITF*, https://www.itf-oecd.org/reversing-car-dependency (accessed on 22 June 2022). [89]

ITF (2019), "Benchmarking Accessibility in Cities", *International Transport Forum Policy Papers*, No. 68, OECD Publishing, Paris, https://www.itf-oecd.org/benchmarking-accessibility-cities (accessed on 10 June 2022). [87]

ITF-OECD (2017), *Income Inequality, Social Inclusion and Mobility Roundtable Report 2017 Income Inequality, Social Inclusion and Mobility*, https://www.itf-oecd.org/sites/default/files/docs/income-inequality-social-inclusion-mobility.pdf (accessed on 4 June 2019). [72]

Kampman et al. (2011), *Impacts of Electric Vehicles - Deliverable 5 Impact analysis for market uptake scenarios and policy implications*. [37]

Lakoff, G. and M. Johnson (2008), *Metaphors We Live By*, University of Chicago Press, https://books.google.com/books/about/Metaphors_We_Live_By.html?id=r6nOYYtxzUoC (accessed on 15 July 2022). [28]

Lamb, W. et al. (2021), "A review of trends and drivers of greenhouse gas emissions by sector from 1990 to 2018", *Environmental Research Letters*, Vol. 16/7, p. 073005, https://doi.org/10.1088/1748-9326/abee4e. [27]

Le Parisien (2021), *Pérennisation des coronapistes : à Paris, la piste cyclable de la rue de Rivoli change de look*, https://www.leparisien.fr/paris-75/perennisation-des-coronapistes-a-paris-la-piste-cyclable-de-la-rue-de-rivoli-change-de-look-08-12-2021-OGDCK6N6OVA2PP7MUDYQKQBQRU.php (accessed on 28 June 2022). [95]

Leard, B., J. Linn and K. Cleary (2020), *Carbon Pricing 202: Pricing Carbon in the Transportation Sector: What are the effects of a carbon price on the transportation sector, from fuel prices to total miles traveled?*, Resources for the Future: Explainer, https://www.rff.org/publications/explainers/carbon-pricing-202-pricing-carbon-transportation-sector/ (accessed on 27 September 2022). [75]

Lévay, P., Y. Drossinos and C. Thiel (2017), "The effect of fiscal incentives on market penetration of electric vehicles: A pairwise comparison of total cost of ownership", *Energy Policy*, Vol. 105, pp. 524-533, https://doi.org/10.1016/J.ENPOL.2017.02.054. [49]

Mattioli, G., Z. Wadud and K. Lucas (2018), "Vulnerability to fuel price increases in the UK: A household level analysis", *Transportation Research Part A: Policy and Practice*, Vol. 113, pp. 227-242, https://doi.org/10.1016/j.tra.2018.04.002. [80]

Meadows, D. (2008), *Thinking in Systems*, Chelsea Green, https://www.chelseagreen.com/product/thinking-in-systems/ (accessed on 8 March 2021). [3]

Meadows, D. (1999), *Leverage Points: Places to Intervene in a System*, The Donella Meadows Project: Academy for Systems Change, https://donellameadows.org/archives/leverage-points-places-to-intervene-in-a-system/ (accessed on 11 July 2022). [32]

MIT Energy Initiative (2019), *Insights into Future Mobility - Executive Summary*, MIT Energy Initiative , Cambridge, MA. [54]

Movmi (2019), *Shared Mobility in by Region: UK and Ireland*, https://movmi.net/blog/shared-mobility-uk-ireland/ (accessed on 24 June 2022). [99]

Mukherjee, S. and L. Ryan (2020), "Factors influencing early battery electric vehicle adoption in Ireland", *Renewable and Sustainable Energy Reviews*, Vol. 118, p. 109504, https://doi.org/10.1016/J.RSER.2019.109504. [42]

Murray, B. and N. Rivers (2015), "British Columbia's revenue-neutral carbon tax: A review of the latest "grand experiment" in environmental policy", *Energy Policy*, Vol. 86, pp. 674-683, https://doi.org/10.1016/J.ENPOL.2015.08.011. [74]

National Transport Authority Ireland (2021), *Greater Dublin Area Transport Studies - Dublin City Center Area Report*. [22]

Norsk elbilforening (2021), *Norwegian EV market*, Norsk elbilforening. [111]

NTA (2022), *Core Bus Corridor*, BusConnects, https://busconnects.ie/initiatives/core-bus-corridors/ (accessed on 11 July 2022). [67]

OECD (2021), *Effective Carbon Rates 2021: Pricing Carbon Emissions through Taxes and Emissions Trading*, OECD Publishing, Paris, https://doi.org/10.1787/0e8e24f5-en. [83]

OECD (2021), *OECD Environmental Performance Reviews: Ireland 2021*, OECD Environmental Performance Reviews, OECD Publishing, Paris, https://doi.org/10.1787/9ef10b4f-en. [57]

OECD (2021), *Transport Strategies for Net-Zero Systems by Design*, OECD Publishing, Paris, https://doi.org/10.1787/0a20f779-en (accessed on 10 June 2022). [10]

OECD (2019), *Taxing Energy Use 2019: Using Taxes for Climate Action*, OECD Publishing, Paris, https://doi.org/10.1787/058ca239-en. [68]

OECD (2018), *Rethinking Urban Sprawl: Moving Towards Sustainable Cities*, OECD Publishing, Paris, https://doi.org/10.1787/9789264189881-en. [17]

Office of Zero Emission Vehicles (2022), *Zero Emission Vehicles Ireland: Information for the general public*, https://www.gov.ie/en/publication/ca752-zero-emission-vehicles-ireland-information-for-general-public/ (accessed on 25 July 2022). [104]

Orsi, F. (2021), *On the sustainability of electric vehicles: What about their impacts on land use?*, Elsevier. [36]

Parliamentary Budget Office Ireland (2022), *An Overview of Ireland's Electric Vehicle Incentives and a Comparison With International Peers*. [35]

Randall, C. (2021), *Norway: with stats from December, stronger EV sales in 2020*, electrive.com. [110]

RTÉ (2022), *New car sales down 25% but EV sales soar - CSO*, Raidió Teilifís Éireann (RTÉ). [47]

Rubiera-Morollón, F. and R. Garrido-Yserte (2020), "Recent Literature about Urban Sprawl: A Renewed Relevance of the Phenomenon from the Perspective of Environmental Sustainability", *Sustainability 2020, Vol. 12, Page 6551*, Vol. 12/16, p. 6551, https://doi.org/10.3390/SU12166551. [64]

Rueda, S. (2020), *Debats in the Official College Arquitects of Catalonia (COAC). Superilles, cap a un nou model de ciutat.*. [93]

Rueda, S. (2019), "Superblocks for the design of new cities and renovation of existing ones: Barcelona's case", in Nieuwenhuijsen, M. and K. Haneen (eds.), *Integrating Human Health into Urban and Transport Planning*, Springer International Publishing, https://doi.org/10.1007/978-3-319-74983-9_8/COVER/. [92]

SCSI (2021), *Real Cost of New Apartment Delivery Report*, Society of Chartered Surveyors Ireland, https://scsi.ie/real-cost-of-new-apartment-delivery/ (accessed on 27 June 2022). [66]

SEAI (2022), *Benefits Of Electric Cars: Why Drive An EV? | Electric Vehicles | SEAI*, https://www.seai.ie/technologies/electric-vehicles/why-drive-electric/ (accessed on 30 May 2022). [106]

SEAI (2022), *Energy Statistics In Ireland | SEAI*, Sustainable Energy Authority Ireland, https://www.seai.ie/data-and-insights/seai-statistics/key-statistics/transport/ (accessed on 14 June 2022). [77]

Small, K. and J. Gomez-Ilbanez (1998), "Road Pricing for Congestion Management: The Transition from Theory to Policy", *University of California Transportation Center, Working Papers*, https://ideas.repec.org/p/cdl/uctcwp/qt8kk909p1.html (accessed on 26 September 2022). [70]

Society of the Irish Motor Industry (2022), *Reducing light fleet carbon emissions to achieve Irish Government targets.*. [39]

Society of the Irish Motor Industry (2022), *SIMI | Motorstats - New Online Vehicle Statistics System*, https://www.simi.ie/en/motorstats (accessed on 10 June 2022). [16]

Soulopoulos, N. (2017), *When Will Electric Vehicles be Cheaper than Conventional Vehicles?*, Bloomberg News Energy Finance. [53]

Sterman, J. (2000), *Business Dynamics*, http://jsterman.scripts.mit.edu/Business_Dynamics.html (accessed on 8 March 2021). [4]

Systems Innovation (2022), *Systems Ecology Introduction*. [26]

Systems Innovation (2021), *Leverage Points A Guide For Systems Innovators*, Si Network, https://media2-production.mightynetworks.com/asset/36886279/Leverage_Points_Guide.pdf?_gl=1*11t7147*_ga*MTk1ODAzODMyMS4xNjYwMjIyMzI5*_ga_T49FMYQ9FZ*MTY2MzA2NDQ1MC4xMS4xLjE2NjMwNjQ0NzUuMC4wLjA. (accessed on 18 July 2022). [33]

Systems Innovation (2021), *Nonlinear Systems: An Overview*. [6]

Systems Innovation (2020), *Systems Theory*, https://www.systemsinnovation.io/post/systems-theory-guide (accessed on 25 March 2021). [5]

Szymkowski, S. (2021), *Volkswagen foresees EV price parity with ICE by 2025, 50% EV sales by 2030*, CNET. [52]

Te Brömmelstroet, M. (2020), *Mobility Language Matters*, De Correspondent. [29]

TFI Bikes (2022), *Home - TFI Bikes*, https://www.bikeshare.ie/ (accessed on 24 June 2022). [98]

The Irish Times (2022), *What do the truckers protesting in Dublin want?*, https://www.irishtimes.com/news/ireland/irish-news/what-do-the-truckers-protesting-in-dublin-want-1.4849837 (accessed on 11 July 2022). [84]

The Irish Times (2019), *Sandyford site with planning for over 450 homes makes €38m*, https://www.irishtimes.com/business/commercial-property/sandyford-site-with-planning-for-over-450-homes-makes-38m-1.3804786 (accessed on 27 June 2022). [107]

TII (2019), *National Transport Model Update - Travel Demand Forecasting Report, NTpM Vol 3*, Transport Infrastructure Ireland. [11]

Transport Infrastructure Ireland (2017), *Submission to the Select Committee On Budgetary Oversight*. [9]

van Dender, K. (2019), "Taxing vehicles, fuels, and road use: Opportunities for improving transport tax practice", *OECD Taxation Working Papers*, No. 44, OECD Publishing, Paris, https://doi.org/10.1787/e7f1d771-en. [69]

Wilson, B. and A. Chakraborty (2001), "The Environmental Impacts of Sprawl: Emergent Themes from the Past Decade of Planning Research", Vol. 5, pp. 3302-3327, https://doi.org/10.3390/su5083302. [63]

WIRED UK (2022), *People Hate the Idea of Car-Free Cities—Until They Live in One*, https://www.wired.co.uk/article/car-free-cities-opposition (accessed on 11 July 2022). [96]

WSP and RAND Europe (2018), *Latest Evidence on Induced Travel Demand: an Evidence Review*, Department of Transport, London, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/762976/latest-evidence-on-induced-travel-demand-an-evidence-review.pdf (accessed on 27 June 2022). [7]

Zimmerman, B., C. Lindberg and P. Plsek (2009), "A Complexity Science Primer: What is Complexity Science and Why Should I Learn About It?". [30]

Notes

[1] The dynamic is often referred to as "induced demand" in literature, leaving implicit the fact that it refers to the increase in car traffic.

[2] Although induced traffic is highly dependent on the context, scale and location of the system, theoretical calculations show that an average road improvement will result in an increase in base traffic of 10% in the short term and 20% in the long term, assuming that the traffic growth caused by all other causes is projected properly. This is consistent with other variables such as unexpected short-term growth in traffic, greater long-term overall growth in traffic, a growth in the "peak period" of traffic, and limited relief to alternative routes (Cairns, Atkins and Goodwin, 2002[90]).

[3] For instance, Caulfield, Carroll and Ahern (2020[12]) carry out a literature review and analysis of policy options to reduce emissions in the sector in Ireland. This work is referred to where relevant throughout this section.

[4] The system's physical lock-in is linked to the notion of hysteresis. The notion of hysteresis emphasises the dependence of a system state on its memory or history and the importance that past events have in shaping the system's results today (Systems Innovation, 2022[26]).

[5] By visually illustrating how long it may take to achieve a desired outcome, stock and flow analysis can trigger questions that may inform policy design, and not just their assessment (e.g. in policy co-creation exercises, as tried out during the April 2022 workshops). For example, if the speed of change is insufficient, discussions of qualitatively different actions (e.g. reducing stocks) can be triggered.

[6] For example, not all actions in the new SMP are included.

[7] The level of attention and funding is a dimension not shown in Figure 3.16.

[8] As well as other vehicle technology (e.g. hydrogen-powered vans) and fuel incentives.

[9] On average, the cost of driving EVs is 70% lower than the cost of driving ICEVs in Ireland (Department of Transport Ireland, 2022[34]).

[10] The larger the EV subsidies, the lower the cost of driving and owning a car, the higher the attractiveness of driving and owning a car.

[11] The direct rebound effect in transport is the degree to which a reduction in the cost of travel (by a change in technology) translates into increased kilometres driven (IPCC, 2014[85]), offsetting some, and sometimes all, environmental benefits from the technological efficiency gain.

[12] Curtilage refers to "the land surrounding a building that belongs to the owner of the building and for which he or she has responsibility" (Cambridge Dictionary, 2022[109]).

[13] According to the DoT, this is plausible if maintaining scrappage rates seen in the last 2 years (between 7%-7.5% in average and going up to 24% for gasoline vehicles with >18 years). The department will likely be making updates to the fleet model as data from the end of 2022 becomes available to gain a better understanding of the impact of Covid-19 on vehicle registrations/scrappage.

[14] EV sales accounted for 54.3% of total sales in 2020 (Randall, 2021[110]), which increased by 10% to 64.5% in 2021 (Norsk elbilforening, 2021[111]).

[15] Other studies indicate the process will take longer. As discussed in (Caulfield, Carroll and Ahern, 2020[12]), a study from the Massachusetts Institute of Technology projects a decrease of 50% in the cost of EV batteries by 2030, which is less than that reported in the CAP (67%).

16 Some EV models are SUVs, thus, the two are not mutually exclusive.

[17] Proposals to reduce public transport prices and make public transport free (Caulfield, Carroll and Ahern, 2020[12]) can also jeopardise efforts to increase investment aimed at improving the attractiveness of the mode.[1717] As discussed in (OECD, 2021[10]), the idea of subsidising public transport should not be excluded and targeted subsidies (preferably based on affordability criteria) should be preferred. Correcting under-priced car use, which contributes to making public transport relatively expensive, must also be a priority (OECD, 2021[10]).

[18] Detached houses with their own sewerage system.

[19] The majority of these one-off houses were built before 2011.

[20] In rural areas, the target is 30%.

[21] The words “infill” and “brownfield” are used interchangeably to describe potential sites for development in the cited policy documents, but they are different concepts and should be treated differently (see section 4.6.1 for discussion and recommendations).

[22] Greenfield development is defined as development that extends the physical footprint of urban areas (Government of Ireland, 2018[61]).

[23] Interviewed officials pointed to cultural preferences in Ireland for detached/one-off houses with gardens as a key driver of greenfield development and urban sprawl (Department of Transport, 2022[48]).

[24] The report uses Ballyogan Road in Leopardstown and Sandyford Industrial Estate as examples of suburban development sites (SCSI, 2021[66]). They are both greenfield sites on the outskirts of Dublin near the M50 motorway (Dún Laoghaire-Rathdown County Council, 2019[108]; The Irish Times, 2019[107]). North of Dublin Docklands, a brownfield site in central Dublin, serves as an example of an urban site (SCSI, 2021[66]).

[25] The programmes are grouped together here as one policy; however, individual actions can be classified differently if evaluated on their own (see Annex B).

[26] The carbon tax rate will be gradually raised from €33.50 to €100 per tonne over the period 2021–2030.

[27] As discussed in chapter 4, setting a target that covers solely ICE kilometres (rather than total car travel) is not in line with the aim of reducing congestion and total traffic volumes, and more largely with the aim of shifting away from car dependency

[28] Low-emission zones can, in the short run, work like road pricing and help to slow down induced car demand (by restricting access to the dirtiest vehicles). However, evidence (e.g. from Milan) shows that they serve mostly to accelerate vehicle renewal, and as the fleet becomes cleaner traffic in the restricted area increases again. In Milan the low-emission zone was turned into a hybrid model that combines road pricing for all vehicles with a ban on the most polluting ones (OECD, 2021[10]). The presence of low-emission zones can incentivise hybrid vehicles to be driven in geo-fencing mode just before entering the zone (to charge the battery). The gap between on-road and laboratory-environment emissions is particularly high during driving in geo-fencing mode (OECD, 2021[10]).

[29] This is different from EV incentives, for instance, which are also anticipatory but aim at decarbonising growing car traffic rather than containing it.

[30] In the case of a uniform carbon price, the cost of fuel will increase proportionally to fuels carbon content

[31] The higher the uptake of electrification and the higher the improvements in fuel efficiency, the more this will become an issue.

[32] Regular updates in prices could help mitigate this phenomenon. However, acceptability of carbon pricing is challenging in car-dependent systems where good transport alternatives are limited or inexistent to many (see more discussion below).

[33] The authors develop a vulnerability index to fuel price increases by combining exposure (cost burden of motor fuel), sensitivity (income level) and adaptive capacity (access to alternative transport infrastructure) (Mattioli, Wadud and Lucas, 2018[80]). Analysis based on this type of index can help identify vulnerable households, infrastructure gaps and necessary compensatory measures, as well as potential acceptability issues related to carbon pricing increases.

[34] With a growing population, the effect on total as opposed to per-capita travel will be even smaller if trends continue.

[35] Including the reallocation of parking space, which makes up a large amount of the space granted to car use.

[36] On-demand schemes introduce new services, business models and types of vehicles unavailable or marginal in the current transport system. The mainstreaming of on-demand services facilitates the development of multi-modal networks able to offer door-to-door connections, and the private sector engagement can speed up this development. For example, e-scooters, e-bikes, e-cargo bikes, on-demand micro-transit and car-sharing schemes are offered to the public via leasing or other subscription modes. These newly available services increase the alternatives to the car and

the length and type of trips possible via active modes (e.g. buying groceries, transporting family, facilitating use by the elderly), and strengthen public transport connectivity.

[37] Because they complement public transport, the expansion of on-demand services can also increase the attractiveness of public transport services.

[38] The CCCC replaces the Interdepartmental Group on Climate Communications established in 2019.

[39] Technological optimism refers to the idea that "technological improvements will allow countries to reduce emissions at the pace and scale needed. It sees technology as a way to increase vehicle performance (in terms of speed, fuel consumption, emissions, etc.), rather than improving the way systems are organised, where technological potential is mostly untapped and could lead to enormous emission reductions" (OECD, 2021[10]).

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