Smart Control of Air Pollution

**Policy Briefs** from the **iSCAPE** project funded by the European Union's Horizon 2020 Research and Innovation Programme

# Simulating change in urban air quality and climate conditions

Contents



## Key Take-Aways

**Simulation modeling delivers a structured process to predict changes in dispersion of air pollutants and urban thermal comfort.**

Simulation modeling solves real-world problems safely and efficiently, in a manner that can be verified, providing valuable solutions with clear insights into complex systems.

Simulation modeling also provides a safe way to test and explore different "what-if" scenarios, allowing risk quantification for more robust solutions to be found.

In the iSCAPE project, simulation models were extensively used to investigate the effects of physical interventions, policy interventions, and behavioural changes on air pollution and climate change at a neighborhood and urban level, as well as to analyse the impact of climate change in European cities.

As such, more than a single model, iSCAPE has delivered a structured process to predict changes in dispersion of air pollutants and urban thermal comfort, as impacted by the various infrastructural and policy interventions, verified against real-world observations. In light of the positive features displayed by the proposed approach in a variety of policy relevant domains, we believe that the time is ripe for local decision-makers to become competent with simulation modeling logic first, and then of its numerous possible applications.

> **"It looks a bit like building a new bridge between science and policy making".**
>
> One of the policy experts involved in the project.




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# The Concept

## An executive introduction to simulation modeling as a decision making support tool for public policies.

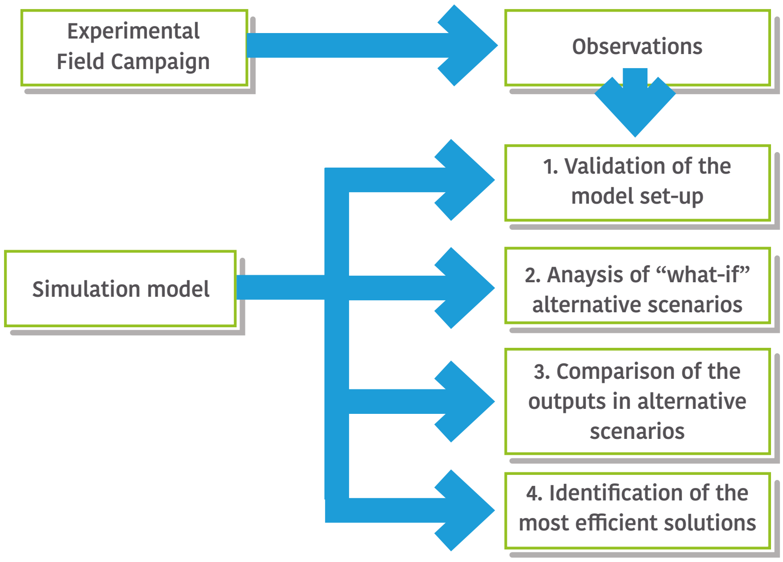


**Figure 1:** The concept and various steps of simulation modeling.

The idea behind simulation modeling is relatively simple, as Figure 1 describes. Observations from an experimental field campaign are often not enough to support the adoption of a certain intervention or strategy.

However, field observations are useful to validate the configuration (set-up) of a simulation model, making it more robust and reliable when presenting possible alternatives. These so called "what if" scenarios represent what could materialise in the near future, with or without the implementation of a certain policy or strategic intervention. In this case, **simulation modeling presents itself as a credible contribution to evidence based decision-making**.

Naturally, a key condition is that the selected model should be capable of reproducing the behaviour of the real-world structures (including people and communities) it aims to simulate. Therefore, the field campaigns needed to validate the simulation models initially developed in order to be carefully settled. In the next chapter we present a number of concrete application cases whereby simulation modelling was successfully utilised at an urban and/or neighbourhood scale to assess the impact of different environment-related decisions within the six European cities participating in the iSCAPE project.

The **six fundamental steps** required to implement the concept outlined in Figure 1 are the following:

1. Plan and set-up of the experimental field campaign to gather the required observation data;
2. Set-up of the simulation model;
3. Gather real-world observations, to be used in two directions: on the one hand, to validate the set-up of the simulation model in

the current conditions, on the other hand, to analyse the impact of a certain intervention by means of real-world observations;

4. Run repeated simulations ("what if" scenarios) each corresponding to the outputs of various interventions (single and/or in combination) managed at neighbourhood/urban scale and possibly accounting for the impacts of climate change;

5. Compare the results of each simulation until the most appropriate solution (i.e. decision or intervention) is identified.

The following Figure 2 illustrates the structured process used in iSCAPE to simulate the impact of policy and infrastructural interventions on air quality at an urban and neighborhood level, and its consequences on personal exposure to pollution.

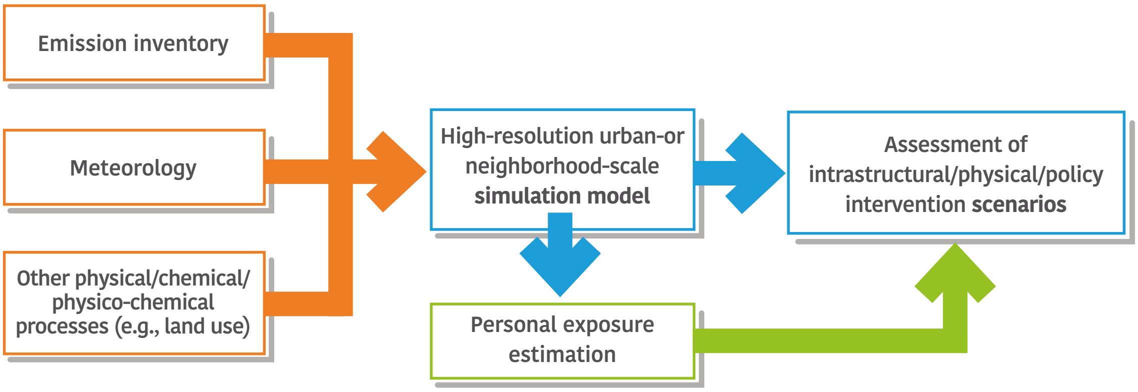


**Figure 2:** Structured process used to simulate the impact of physical and policy interventions on air quality and personal exposure estimation in the iSCAPE project.

In Figure 2, real-world observations come from three main sources: **air pollutants** (leading to an inventory of emissions), **weather data** (opening a window on climate change impacts), and **other location- specific processes** (such as related to land use and spatial planning in the city). As a derivative from the simulation model, the iSCAPE process also generated estimates of the individual exposure to air pollution, which have been successfully used in several field campaigns to reinforce existing perceptions of environmental damage and drive a more intense and faster change in personal travel or commuting behaviours.

As a result of this structured approach, the final comparative assessment of alternative solutions in terms of policy and infrastructural interventions could also include the expected reactions of the urban communities involved or not yet involved in the project initiatives and experimentations.

Based on the hands-on experience gathered within the project pilots, and summarized in the following section we can conclude that simulation modelling represents a rather unique and powerful tool for synthesising and leveraging existing (even diverse and uncorrelated sources of) evidence in order to formulate credible hypotheses on the likely impacts of alternative policy scenarios.

The ultimate benefits of simulation modeling include, among others:

- The possibility of exploring the consequences of new and never tried interventions (before real-life implementation);
- The minimisation, as well as the comparative appraisal, of the risk factors associated with certain interventions; and
- The identification of gaps in observations to be prioritised for the fulfilment of new action research needs.

An additional, but not less important, benefit that became evident in the context of the iSCAPE pilots has been the creation of local communities of interest engaging researchers, alongside policy makers and other urban stakeholders, including normal citizens, in the preparatory and interpretive activities associated with the use of data for simulation purposes. These multiple communities – born to last in each pilot city – have contributed not only to supporting the argument that the "simulation modeling matters" for policy innovation, but also to strengthening a collaborative relationship among all actors interested and actively involved in that specific topic at urban level.

# Application Cases

## A collection of concrete experiences of using simulation modeling in the urban policy realm.

This section summarises the results of the main activities related to simulation modeling performed to date within the six European city pilots of the iSCAPE project (Bologna-IT, Bottrop-DE, Dublin-IE, Guildford-UK, Hasselt-BE and Vantaa-FI) in a variety of policy relevant domains at urban and neighbourhood levels, notably:

### Comparative assessment of strategies to reduce car traffic

Adopting the iSCAPE behavioural simulation model in Bologna, Hasselt and Vantaa, it was found that policies aimed at restricting car traffic are the most effective in terms of reducing air pollution and shifting car drivers / passengers to other modes of travel. On the contrary, the enhancement of bus infrastructure by increasing the frequency of routes and also tweaking activity time (changing open and end times) are not able to significantly reduce car traffic and present controversial effects on air quality. Especially, improvement of bus infrastructure causes the shifting of cyclists towards public transport, which is an undesirable result of the policy change.

### Dependency of measures to reduce air pollution on climate change scenarios

Introducing the dimension of time in the evaluation of the efficacy of alternative policy interventions may lead to consider the dependency of such interventions' outputs on the concurrent dynamics of climate change at the urban level. This was accomplished in the same three iSCAPE cities of Bologna, Hasselt and Vantaa, being representative of southern, central and northern Europe, respectively. Detailed air quality maps were reconstructed, using a well-validated dispersion model and taking into account the likely environmental effects of collective behavioural actions such as telecommuting and starting/ending times of work as well as the number of cold and warm starts. The results of the simulations conducted in the current scenario highlighted the presence of different air pollution hotspots in the cities. Indeed, policies adequately set-up in view of the major hotspots identified were revealed to be effective in improving air quality both in the present as well as in future climate scenarios.

### Climate change influences on the efficacy of passive control solutions

These solutions include trees, hedges and vegetation, green walls and green urban spaces, which reduce personal exposure to pollution by changing air flow patterns and improving urban thermal comfort. Their adoption has been proven effective by several empirical studies, both in terms of altered dispersion patterns and improved air quality and reduced air temperatures in built environments.

But what can be predicted for the medium to long term, considering the impacts of climate change? In the three cities of Bologna, Dublin and Guildford, the effects of various meteorological conditions on specific reduction targets have been addressed by several simulations. Moreover, simulations were also conducted for the cities Bologna, Dublin and Vantaa, to assess the effectiveness of interventions in a future scenario accounting for climate change. The recommendations drawn from the analysed data can be used to formulate solid policy options for future interventions in other European cities.

### Effects of alternative passive control solutions on urban air quality

In the five pilots of Bologna, Bottrop, Dublin, Guildford and Vantaa, a comparative assessment of different urban infrastructural interventions carried out at a neighbourhood level has been provided in dependence of the various morphological and microclimate conditions of the intervention targets. Figure 3 presents examples of the simulation set-ups adopted in Bottrop and Vantaa. Numerical simulation helped to document and analyse the effectiveness of various passive control solutions in reducing air pollution exposure and improving thermal comfort for the citizens.

Overall, the structured process outlined in the previous section was used to simulate the impact of behavioural interventions, infrastructural interventions and other policy innovations on air quality, urban thermal comfort and personal exposure of citizens to air pollution, not only in the current scenario after simply changing the emission inventory, but also in a future climate change scenario, where meteorological conditions will be different.

In addition, by changing the kind and resolution of the model, it was possible to simulate the impact of the same intervention at various scales, providing information with variable levels of details.

As such, once the simulation model is verified against observations gathered within the real world observations, its outputs truly offer a precious tool to support project-evaluation and adequate urban planning, providing the possibility of comparing and/or considering the implementation of various kinds of interventions in the set-up.

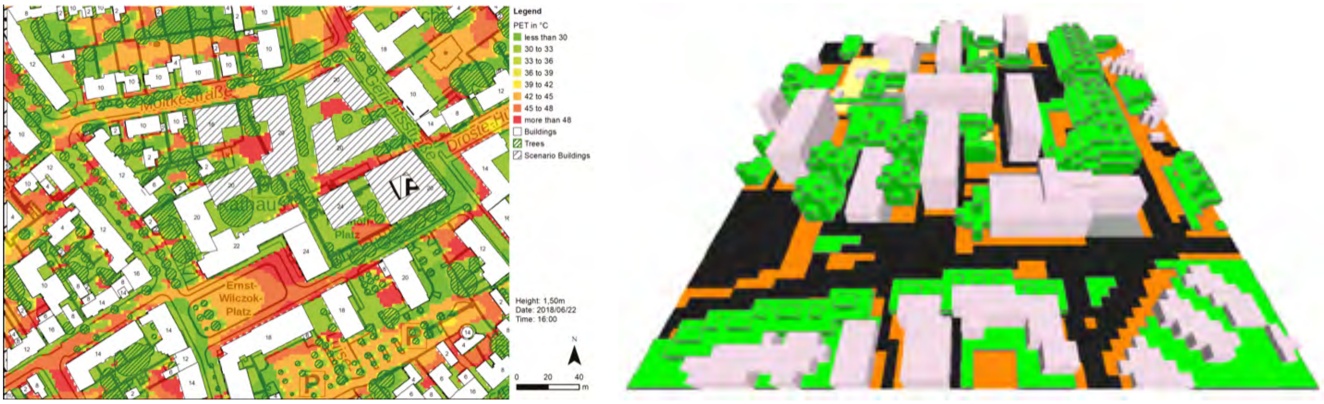


**Figure 3:** Examples of the simulation set-ups adopted in Bottrop (left) and Vantaa (right); cf. iSCAPE D6.3.

> **"So, simulation modeling really matters for policy innovation!"**
> One of the policy experts involved in the project.

## Keywords to remember

**Behavioural Change Interventions:**
Actions and initiatives taken to influence individual behaviour in a specific domain such as mobility, energy conservation, recycling, pollutant exposure reduction.

**Passive Control Systems:**
Green and built urban infrastructure for air quality and/or urban thermal comfort improvement, including e.g. low boundary walls, trees and hedges, green walls and roofs, photocatalytic coatings, green urban spaces and road geometry interventions.

**Simulation Model:**
A mathematical model that calculates the impact of uncertain inputs and decisions we make on outcomes that we care about, such as profit and loss, investment returns, environmental consequences, and the like.

## Read More

The content presented herein is based on the following key project deliverables: **D4.4** 'Prototype of a Fully Integrated Behavioural (Data-Driven) Simulator' (February 2019), **D4.5** 'Report on Policy Options for Air Quality and Climate Change' (February 2019), **D6.2** 'Microscale Computational Fluid Dynamics Evaluation of Passive Control Solutions Impacts on Air Quality' (February 2019), **D6.3** 'Detailed Report Based on Numerical Simulations of the Effect of Passive Control Solutions at the Urban Level' (February 2019), **D6.4** 'Detailed Report on Local Meteorological Conditions' (July 2019), **D6.5** 'Detailed report of the effect of PCSs on air quality in the future CC (2050) in the target cities' (July 2019) and **D7.3** 'Behavioral Recommendations for Urban Anthropogenic activities to population exposure and human health' (November 2019).

All reports are available on the iSCAPE project website: www.iscapeproject.eu

## Impressum

### Acknowledgements and Disclaimer

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## The iSCAPE project

iSCAPE aimed to reduce urban air pollution and the negative impacts of climate change by leveraging sustainable passive control systems, behavioural change initiatives and the Living Lab approach.

For more information: www.iscapeproject.eu.

**iSCAPE partners:**

- University College Dublin
- University of Bologna
- University of Surrey
- Finnish Meteorological Institute
- Hasselt University
- TU Dortmund University
- JRC - Joint Research Centre - European Commission - Institute for Environment & Sustainability
- Institute for Advanced Architecture of Catalonia - FabLab Barcelona
- T6 Ecosystems S.r.l.
- Nanoair Solutions S.r.l.
- Future Cities Catapult Ltd.
- Dublin City Council
- Regional Agency for Prevention, Environment and Energy of Emilia-Romagna
- European Network of Living Labs
- Trinity College Dublin

# Smart Control of Air Pollution - Policy Briefs

The Smart Control of Air Pollution - Policy Briefs series summarises key outcomes of the iSCAPE project with a clear policy orientation, to provide practical information to EU local decision-makers and other urban stakeholders. They cover the following topics:

- **No. 1** **Living Labs for air pollution control and prevention**
- **No. 2** **iSCAPE manifesto for citizen engagement in science and policy**
- **No. 3** **Effectiveness of travel behavioural change interventions**
- **No. 4** **Simulating change in urban air quality and climate conditions**
- **No. 5** **Urban strategies and interventions for planning healthier cities**
- **No. 6** **Improving air quality and climate with green infrastructure**
- **No. 7** **Air quality sensing and real time reporting in cities**
- **No. 8** **Introducing infrastructural passive control systems in cities**
- **No. 9** **Citizen Science: a collaborative approach to air pollution control**

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