The Behavioral Dimension of Transport Decarbonization

Michel Bierlaire

Transport and Mobility Laboratory
School of Architecture, Civil and Environmental Engineering
Ecole Polytechnique Fédérale de Lausanne

August 27, 2026

EPFL

Based on joint work published in [Ben-Akiva et al., 2026].

Outline

Transport and climate change

Transport is one of the largest sources of CO_2 emissions.

23%	75%	6 Gt
of global energy-related CO_2 emissions	of transport emissions come from road transport	road transport CO_2 in 2024

Deep decarbonization of transport is essential.

[Shukla et al., 2022]

Why transport is difficult

- Transport demand is derived from activities.
- Mobility needs are diverse and constrained.
- Technologies change faster than habits.
- Infrastructure changes slowly.
- Policy impacts remain uncertain.

The behavioral dimension

- Individuals choose activities and modes.
- Households choose vehicles and locations.
- Firms choose fleets and operations.
- Governments shape incentives and constraints.
- These choices determine emissions.

Outline

Kaya identity

$$\mathrm{CO}_2 = \sum_m \left(\frac{\mathrm{CO}_2}{E}\right)_m \left(\frac{E}{\mathrm{PKT}}\right)_m \mathrm{PKT}_m$$

Fuel	Technology	Behavior
Carbon intensity	Energy intensity	Travel demand

Three levers for decarbonization, each with a behavioral dimension.

Kaya identity as a behavioral map

$\left(\frac{\mathrm{CO_2}}{E}\right)_m$	Which energy carrier is used?
$\left(\frac{E}{\mathrm{PKT}}\right)_m$	Which technology is used?
PKT_m	How much, where, and how people travel?

Each component is shaped by decisions.

Fuel choice

Examples	Electricity, hydrogen, sustainable aviation fuel (SAF)
Behavioral drivers	Cost, availability, infrastructure
Decision makers	Individuals, operators, governments

Fuel decarbonization requires technology and behavioral adoption.

Technology adoption

Behavior determines technology adoption and use.

Electric vehicles	Charging infrastructure, range anxiety
Cycling	Safe infrastructure, perceived safety
Public transportation	Service quality, accessibility
Fuel-efficient vehicles	Lower cost per kilometer $\rightarrow$ more driving (rebound effect)

Behavioral heterogeneity

Context	Ability	Motivation
Infrastructure	Income	Values
Accessibility	Knowledge	Norms
Prices	Household	Perceptions
Regulations	Physical capacity	Emotions

Same policy. Different responses.

What must be modeled?

- Choices, not only technologies.
- Heterogeneity, not only averages.
- Constraints, not only preferences.
- Adoption, not only availability.
- System effects, not only direct effects.

Behavioral realism is needed for policy evaluation.

Outline

Policy instruments

Governments can modify incentives, constraints, and perceptions.

Market	Taxes, subsidies, pricing, permits
Regulation	Standards, mandates, restrictions, bans
Information	Labels, campaigns, education, social norms
Compensation	Rebates, transfers, revenue recycling

Each instrument changes behavior through a different channel.

Policy interactions

Policies rarely act in isolation.

Congestion pricing	Needs public transportation alternatives
EV subsidies	Need charging infrastructure
Carbon pricing	Needs compensation mechanisms
Energy pricing	Affects EV use and charging behavior

Policy packages matter more than single instruments.

Public acceptability

A technically sound policy may still fail politically.

Benefits	Fairness	Trust
Reduced emissions	Who pays?	Transparency
Cleaner air	Who benefits?	Participation
Better accessibility	Who is compensated?	Credible institutions

Acceptability depends on perceived effects and legitimacy.

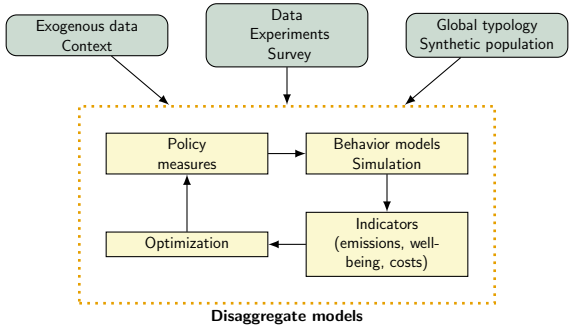
Policies and Kaya components

	Fuel	Technology	Travel
Market	Carbon tax	EV subsidy	Congestion pricing
Regulation	SAF mandate	Fuel economy standard	Low-emission zone
Information	Fuel labels	CO_2 car labels	Mobility campaigns
Compensation	Revenue recycling	Progressive subsidies	Targeted rebates

Policy instruments affect all three Kaya levers.

Outline

Decision-support framework



Policy design as an iterative process.

Behavioral models

Synthetic population

$\Downarrow$

Choice models

$\Downarrow$

Agent-based simulation

$\Downarrow$

Individual schedules and outcomes

Policies are evaluated through simulated decisions.

Behavioral data

Revealed preferences	Observed choices in existing conditions
Stated preferences	Responses to new policies and scenarios
Big data	Large-scale mobility and activity patterns
Data fusion	Context, scale, and behavioral detail

No single data source is sufficient.

Optimization

Simulated decisions

$\Downarrow$

Indicators

$\Downarrow$

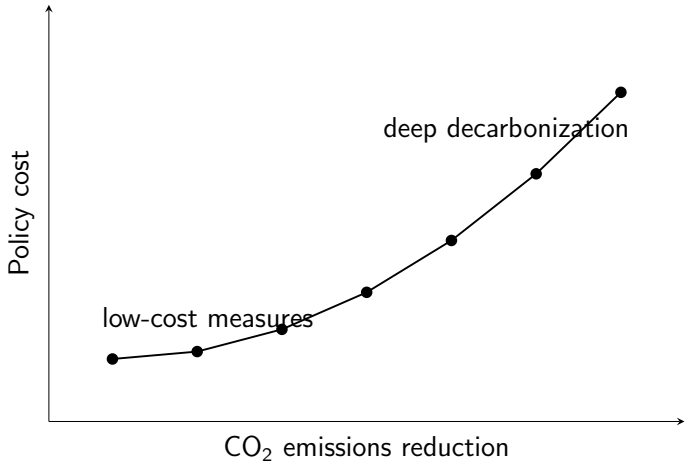
Pareto frontier

$\Downarrow$

Policy revision

Trade-offs are evaluated before implementation.

Optimization trade-offs



More emissions reduction usually requires higher cost.

Outline

Scientific challenges

- Deep uncertainty about future conditions.
- Scalability of disaggregate simulations.
- Calibration with limited behavioral data.
- Validation of policy-sensitive models.
- Multi-scale integration of local and global effects.

Behavioral realism increases scientific difficulty.

Take-home messages

1. Decarbonization is also a behavioral problem.
2. Policies change choices, constraints, and perceptions.
3. Behavioral models predict policy impacts.
4. Data, simulation, and optimization support adaptation.

Effective policies must align technology, behavior, and governance.

Bibliography I

Ben-Akiva, M., Bierlaire, M., Doyme, K., Gershenfeld, S., Picard, N., Schafer, A., Seshadri, R., Sivakumar, A., and Steg, L. (2026).
The behavioral dimension of transport decarbonization.
npj Sustainable Mobility and Transport, 3(3).

Shukla, P., Skea, J., Slade, R., Al Khourdajie, A., van Diemen, R., McCollum, D., Pathak, M., Some, S., Vyas, P., Fradera, R., Belkacemi, M., Hasija, A., Lisboa, G., and Luz, S., editors (2022).
Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.
Cambridge University Press.