Retrofitting obligation

A modelling assessment on French dwellings

L. Vivier and L.-G. Giraudet

Centre International de Recherche sur l'Environnement et le Développement (CIRED)
École des Ponts ParisTech (ENPC)

June 6, 2022

Context

- Bottom-up studies show a mitigation potential up to 85% in Europe and North America for the residential sector *(robust evidence, high agreement)* (Cabeza et al., 2022) and shared belief that this sector is replete with cost-effective abatement opportunities.

[1]cutting greenhouse gas emissions by 55% by 2030 compared to their 1990 levels

Context

- Bottom-up studies show a mitigation potential up to 85% in Europe and North America for the residential sector *(robust evidence, high agreement)* (Cabeza et al., 2022) and shared belief that this sector is replete with cost-effective abatement opportunities.
- French national targets:

[1] cutting greenhouse gas emissions by 55% by 2030 compared to their 1990 levels

Context

- Bottom-up studies show a mitigation potential up to 85% in Europe and North America for the residential sector *(robust evidence, high agreement)* (Cabeza et al., 2022) and shared belief that this sector is replete with cost-effective abatement opportunities.
- French national targets:
    1. European emissions target "Fit for 55"[1] i.e. cut by 40% emissions compared to 2018 level in the residential sector.

[1] cutting greenhouse gas emissions by 55% by 2030 compared to their 1990 levels

Context

- Bottom-up studies show a mitigation potential up to 85% in Europe and North America for the residential sector *(robust evidence, high agreement)* (Cabeza et al., 2022) and shared belief that this sector is replete with cost-effective abatement opportunities.
- French national targets:
  1. European emissions target "Fit for 55"[1] i.e. cut by 40% emissions compared to 2018 level in the residential sector.
  2. 500,000 annual global retrofitting and even 700,000 for the new elected government.

[1] cutting greenhouse gas emissions by 55% by 2030 compared to their 1990 levels

French context

Incentive programmes largely ineffective:

- Tax credit programme was found to benefit to 85% non-additional participants (Nauleau, 2014)(Risch, 2020).

French context

Incentive programmes largely ineffective:

- Tax credit programme was found to benefit to 85% non-additional participants (Nauleau, 2014)(Risch, 2020).
- Zero-interest rate green loan programme (ZIGL) found to significantly under-perform: 40k realized loans p.a. against 400k expected (Eryzhenskiy et al., 2022).

French context

Incentive programmes largely ineffective:

- Tax credit programme was found to benefit to 85% non-additional participants (Nauleau, 2014)(Risch, 2020).
- Zero-interest rate green loan programme (ZIGL) found to significantly under-perform: 40k realized loans p.a. against 400k expected (Eryzhenskiy et al., 2022).
- Carbon tax was the trigger to the Yellow vest crisis.

French context

Incentive programmes largely ineffective:

- Tax credit programme was found to benefit to 85% non-additional participants (Nauleau, 2014)(Risch, 2020).
- Zero-interest rate green loan programme (ZIGL) found to significantly under-perform: 40k realized loans p.a. against 400k expected (Eryzhenskiy et al., 2022).
- Carbon tax was the trigger to the Yellow vest crisis.

Conclusion: only 40,000 annual global retrofitting (Enertech et al., 2021)

Motivation

Need for more radical solution.
Citizens' Convention for Climate (CCC) central proposal : **Retrofitting obligation**

Motivation

Need for more radical solution.
Citizens' Convention for Climate (CCC) central proposal : **Retrofitting obligation**

Suggested backup subsidy program:

- 90% of upfront cost for very low-income,
- 70% of upfront cost for low-income,
- and 30% of upfront cost for other households.

Motivation

Need for more radical solution.
Citizens' Convention for Climate (CCC) central proposal : **Retrofitting obligation**

Suggested backup subsidy program:

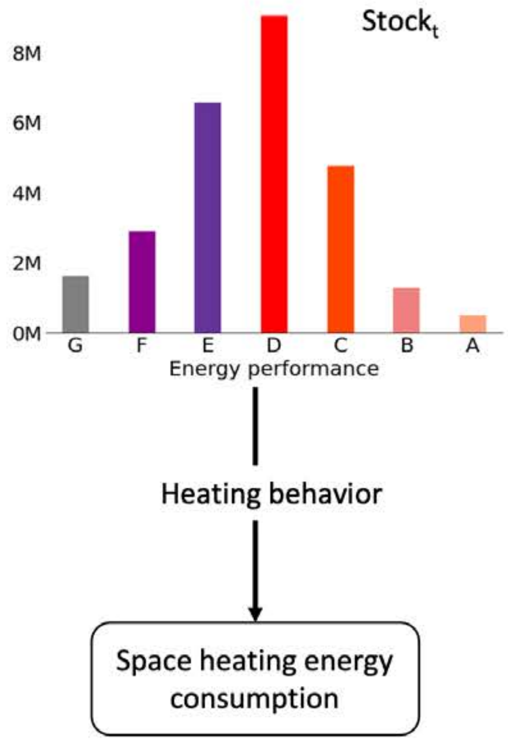
- 90% of upfront cost for very low-income,
- 70% of upfront cost for low-income,
- and 30% of upfront cost for other households.

- **How to practically impose an obligation?**
- **How can subsidies cover the extra cost?**

Methodology

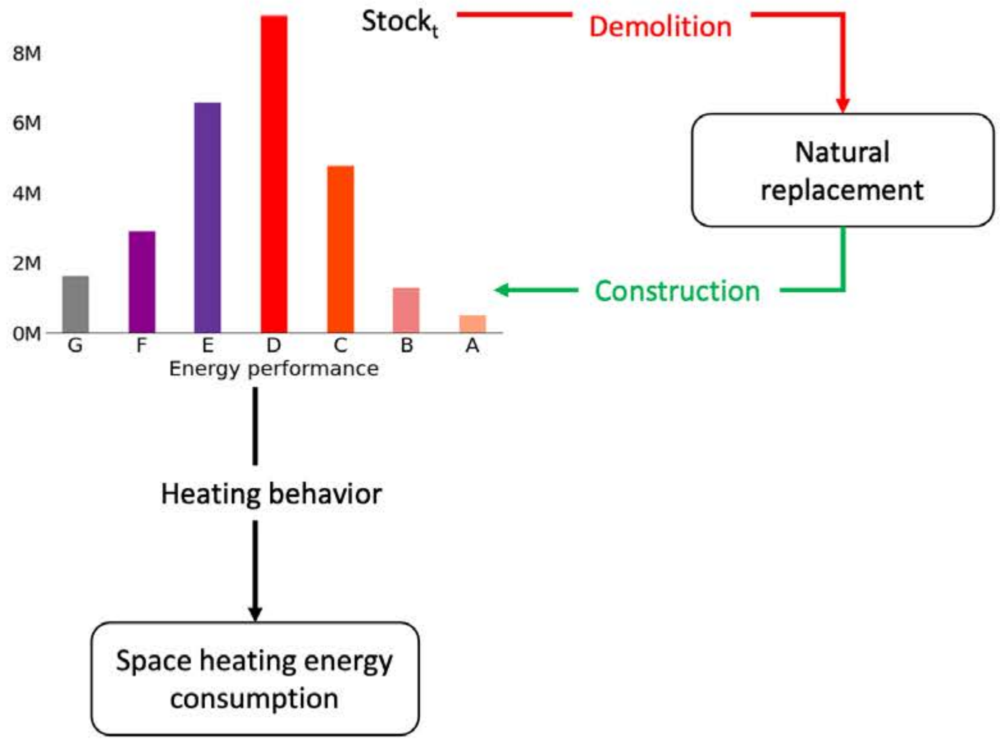
Res-IRF 3.1

Dynamic microsimulation model of residential energy consumption.



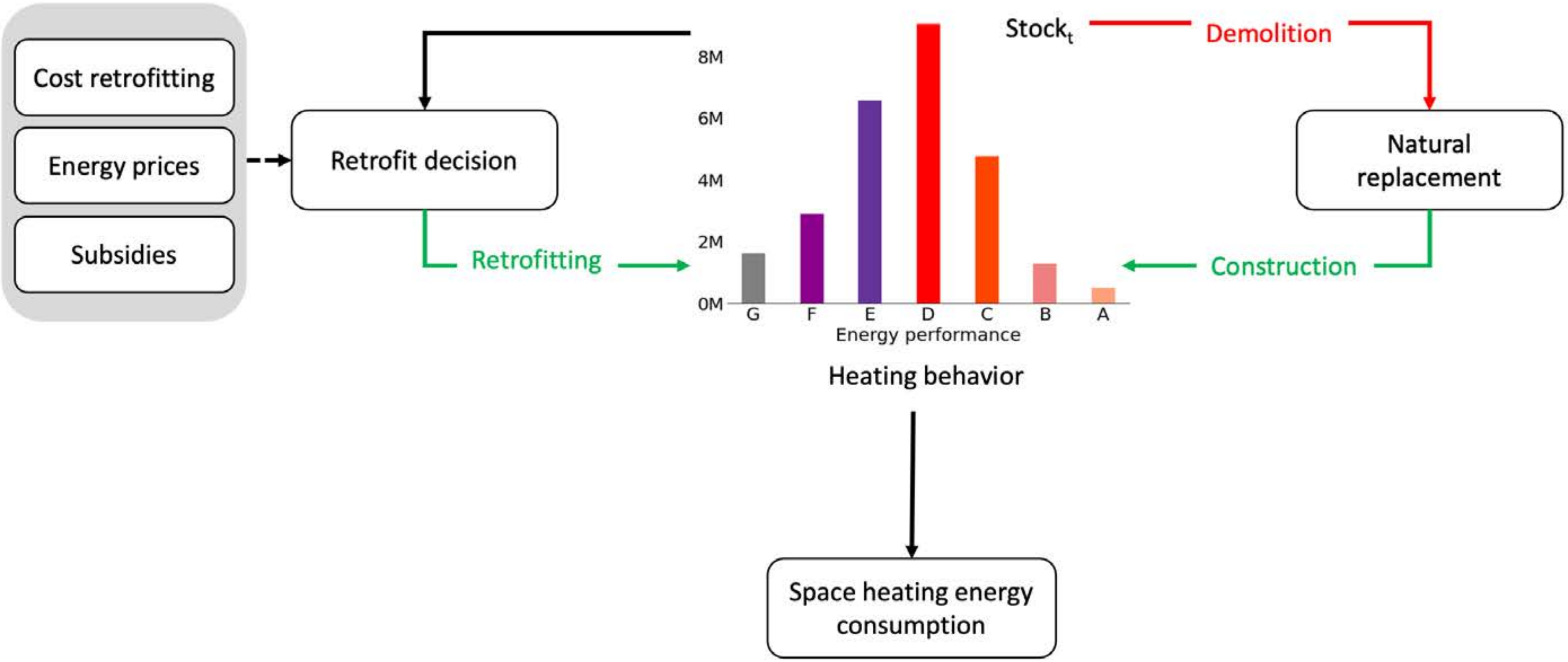
Res-IRF 3.1

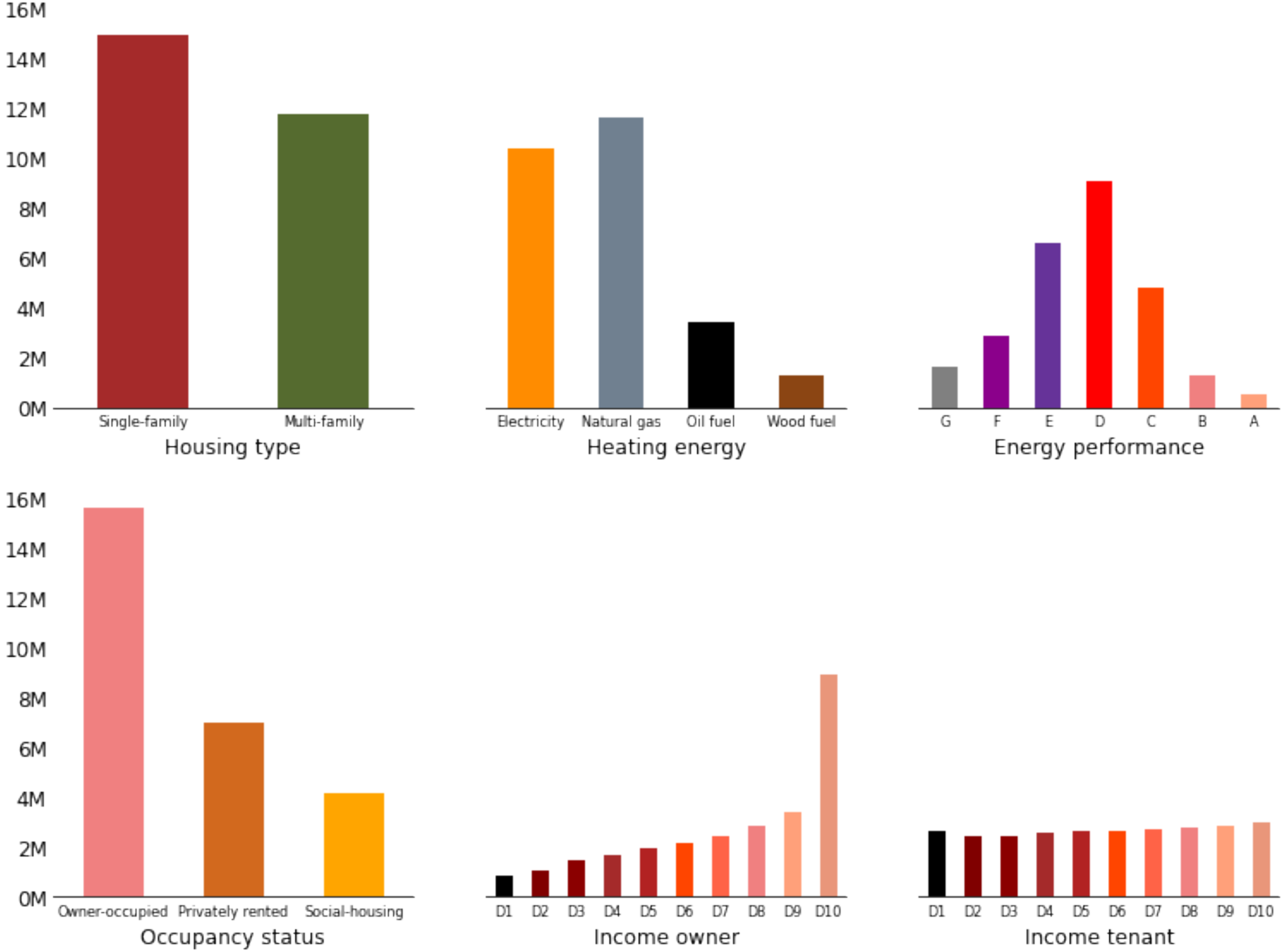
Dynamic microsimulation model of residential energy consumption.



Res-IRF 3.1

Dynamic microsimulation model of residential energy consumption.




16M
14M
12M
10M
8M
6M
4M
2M
0M
Single-family
Multi-family
Housing type
Electricity
Natural gas
Oil fuel
Wood fuel
Heating energy
G
F
E
D
C
B
A
Energy performance
Owner-occupied
Privately rented
Social-housing
Occupancy status
D1
D2
D3
D4
D5
D6
D7
D8
D9
D10
Income owner
Income tenant

Res-IRF key processes

Renovation decisions:

1. Extensive margin: logistic function of NPV[2] of a representative retrofitting project.

[2] NPV: Net present value

Res-IRF key processes

Renovation decisions:

1. Extensive margin: logistic function of NPV[2] of a representative retrofitting project.
2. Intensive margin: discrete choice model based on NPV of specific retrofitting project.

[2] NPV: Net present value

Res-IRF key processes

Renovation decisions:

1. Extensive margin: logistic function of NPV[2] of a representative retrofitting project.
2. Intensive margin: discrete choice model based on NPV of specific retrofitting project.

Model validation:

[2] NPV: Net present value

Res-IRF key processes

Renovation decisions:

1. Extensive margin: logistic function of NPV[2] of a representative retrofitting project.
2. Intensive margin: discrete choice model based on NPV of specific retrofitting project.

Model validation:

- The fitness-for-purpose of the model through global sensitivity analysis (Branger et al., 2015).

[2]NPV: Net present value

Res-IRF key processes

Renovation decisions:

1. Extensive margin: logistic function of NPV[2] of a representative retrofitting project.
2. Intensive margin: discrete choice model based on NPV of specific retrofitting project.

Model validation:

- The fitness-for-purpose of the model through global sensitivity analysis (Branger et al., 2015).
- Its ability to reproduce past trends with great accuracy (Glotin et al., 2019).

[2]NPV: Net present value

Res-IRF key processes

Renovation decisions:

1. Extensive margin: logistic function of NPV[2] of a representative retrofitting project.
2. Intensive margin: discrete choice model based on NPV of specific retrofitting project.

Model validation:

- The fitness-for-purpose of the model through global sensitivity analysis (Branger et al., 2015).
- Its ability to reproduce past trends with great accuracy (Glotin et al., 2019).
- Model and documentation are open-source (Vivier, 2022).

[2] NPV: Net present value

Retrofitting obligation

Occupation status	rented, private	owner-occupied	rented, social
Turnover (%)	12.1%	2.1%	5.2%

Retrofitting obligation

Occupation status	rented, private	owner-occupied	rented, social
Turnover (%)	12.1%	2.1%	5.2%

Obligation imposed on	>G	>F	>E	>D
Enforcement year	2023	2025	2030	2040

Retrofitting obligation

Occupation status	rented, private	owner-occupied	rented, social
Turnover (%)	12.1%	2.1%	5.2%

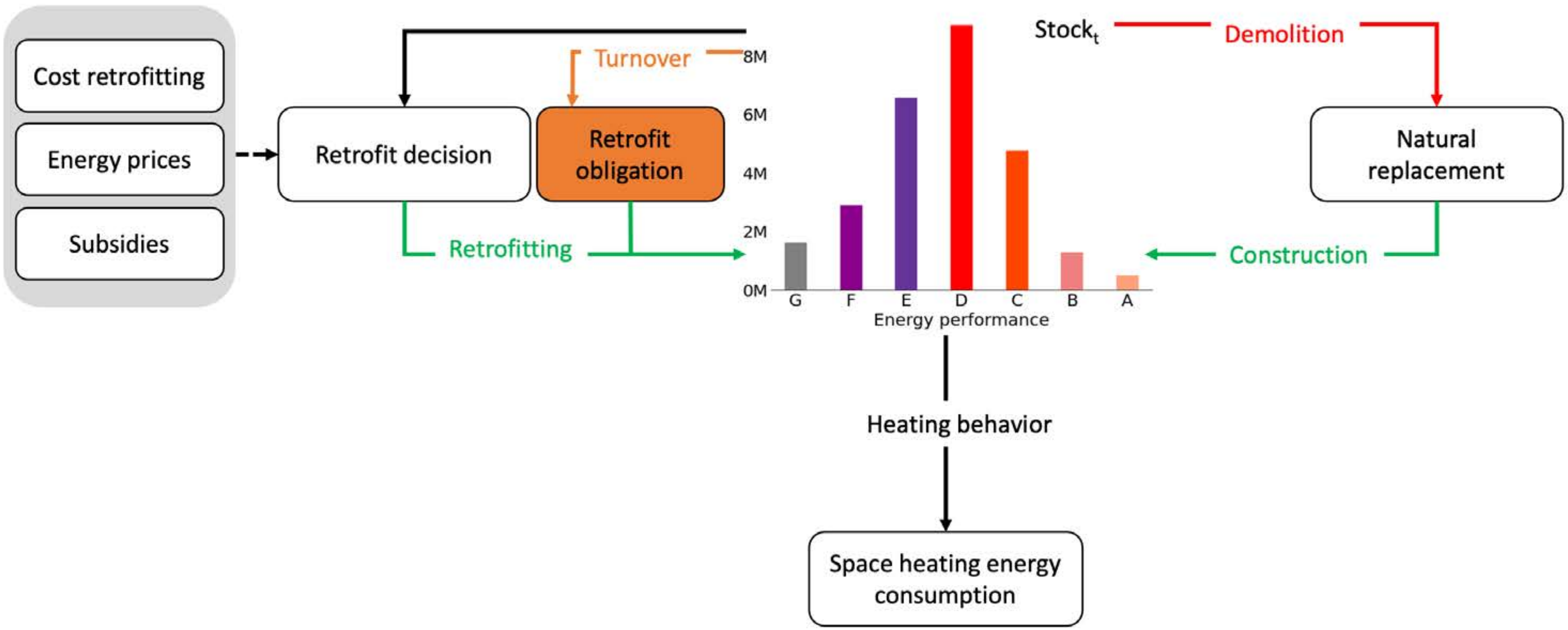
Obligation imposed on	>G	>F	>E	>D
Enforcement year	2023	2025	2030	2040

Scenarios:

- **REF** = Reference, including pre-existing policies
- **OBLIG** = Additional obligation to renovate to label B.
- **SUBS** = Subsidy program, as defined by the CCC.
- **OBLIG+SUBS**

Res-IRF 3.1

Dynamic microsimulation model of residential energy consumption.



Socio-economic assessment

Compare with and without the retrofitting obligation:

Socio-economic assessment

Compare with and without the retrofitting obligation:

- ΔRetrofit cost: additional retrofit costs,

Socio-economic assessment

Compare with and without the retrofitting obligation:

- ΔRetrofit cost: additional retrofit costs,
- ΔEnergy expenditures: reduction in energy expenditures,

Socio-economic assessment

Compare with and without the retrofitting obligation:

- ΔRetrofit cost: additional retrofit costs,
- ΔEnergy expenditures: reduction in energy expenditures,
- ΔEmission: social benefits of avoided CO_2 emissions (Quinet, 2019),

Socio-economic assessment

Compare with and without the retrofitting obligation:

- ΔRetrofit cost: additional retrofit costs,
- ΔEnergy expenditures: reduction in energy expenditures,
- ΔEmission: social benefits of avoided CO2 emissions (Quinet, 2019),
- ΔHealth cost: health benefits, including avoided mortality and morbidity (Dervaux and Rochaix, 2022) due to cold indoor conditions.

Socio-economic assessment

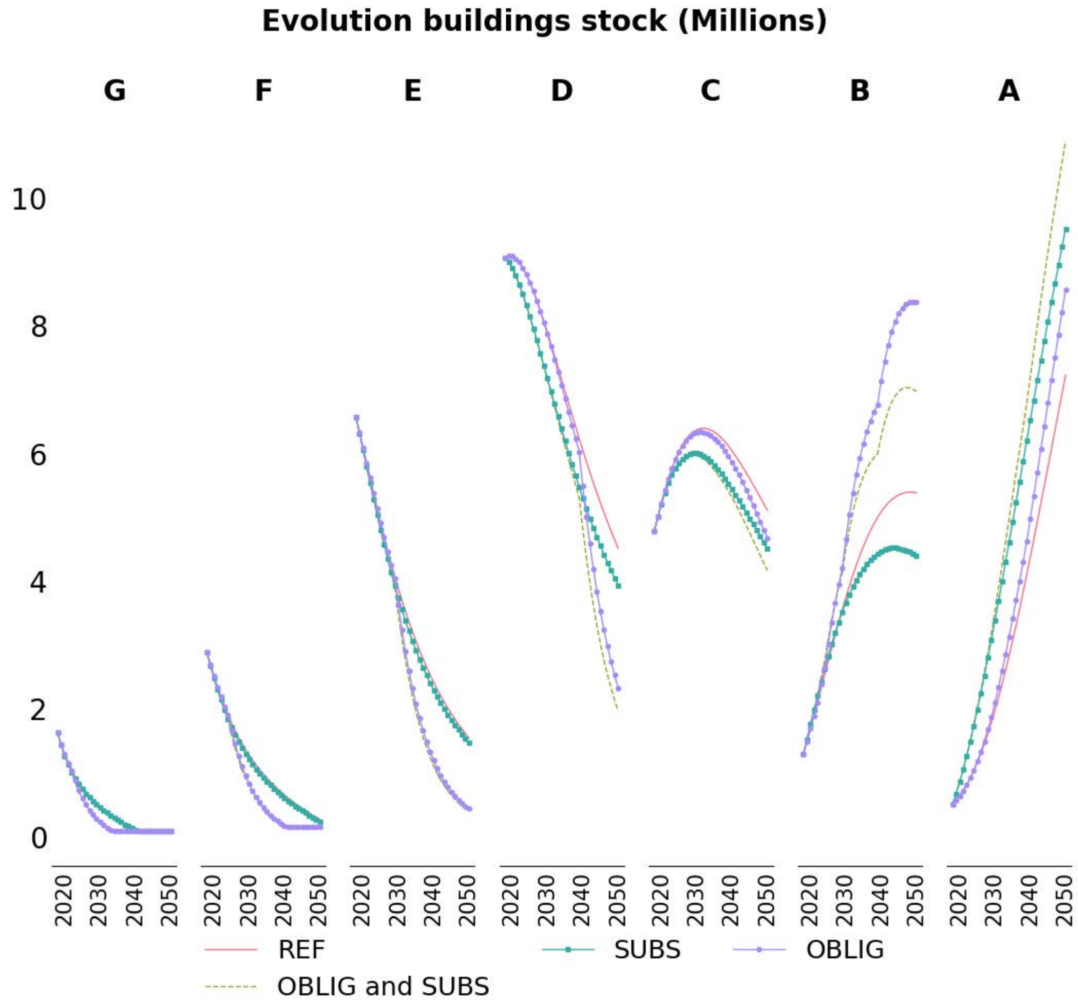
Compare with and without the retrofitting obligation:

- ΔRetrofit cost: additional retrofit costs,
- ΔEnergy expenditures: reduction in energy expenditures,
- ΔEmission: social benefits of avoided CO2 emissions (Quinet, 2019),
- ΔHealth cost: health benefits, including avoided mortality and morbidity (Dervaux and Rochaix, 2022) due to cold indoor conditions.

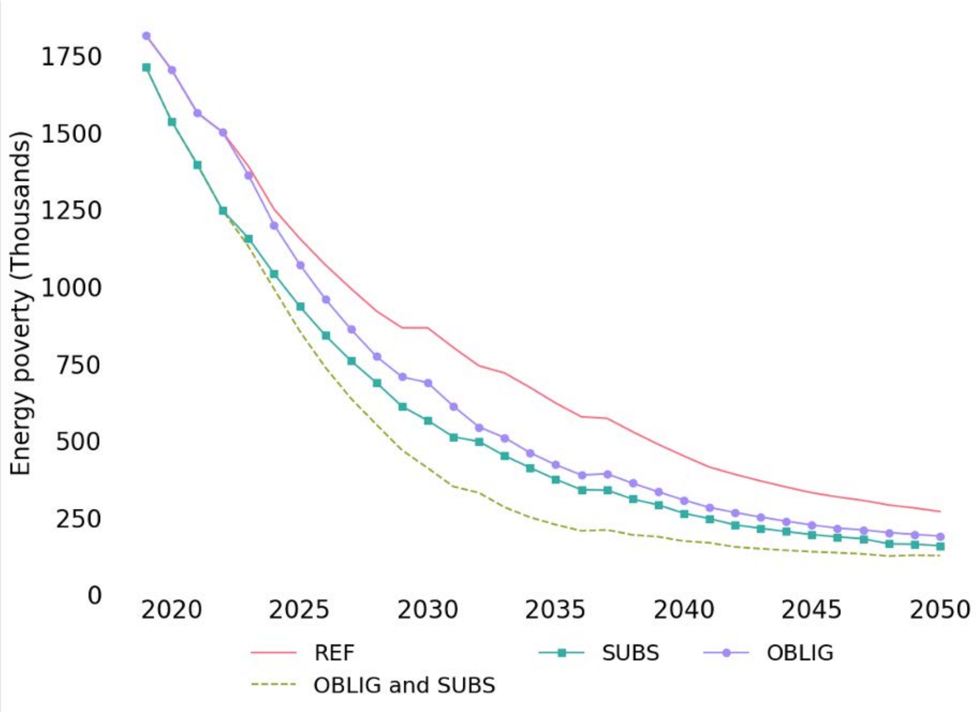
$$\text{NPV} = \Delta\text{Retrofit cost} - \Delta\text{Energy expenditures} - \Delta\text{Emission} - \Delta\text{Health cost}$$

Social discount rate: 4.5%,
Investment horizon: 30 years.

Results


Evolution buildings stock (Millions)
G
F
E
D
C
B
A
10
8
6
4
2
0
2020
2030
2040
2050
REF
SUBS
OBLIG
OBLIG and SUBS

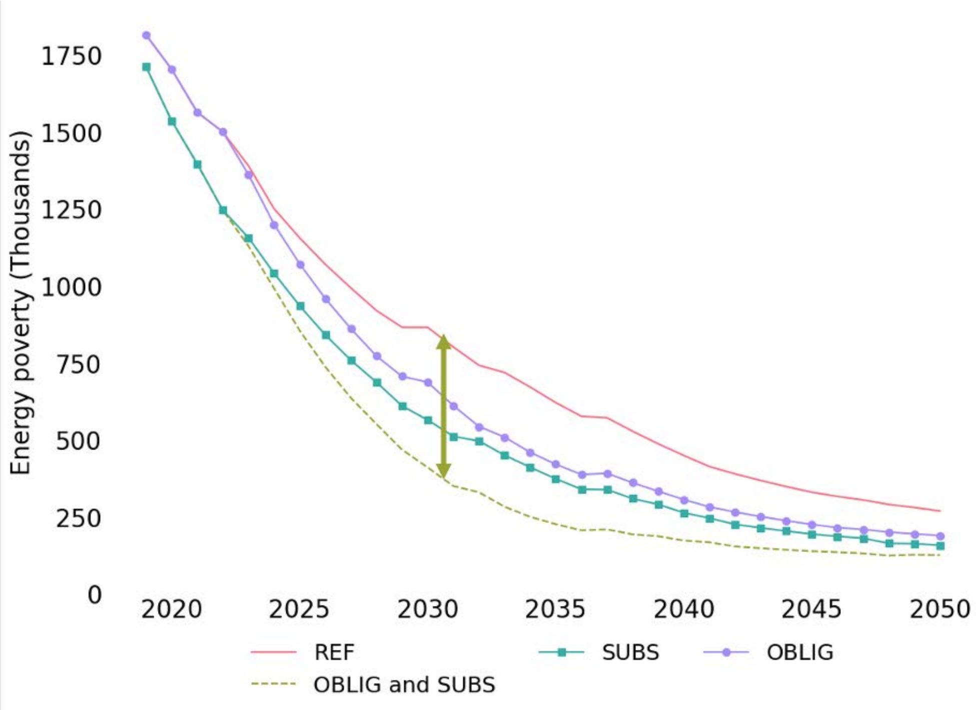
Energy poverty



Fuel poverty assessed by number of households energy-to-income ratio (EIR) $<$ 10%.

$$\text{EIR}_{n,t} = \frac{\text{Consump}_{n,t} \times \text{Price}_t}{\text{Income}_{n,t}}$$

Energy poverty

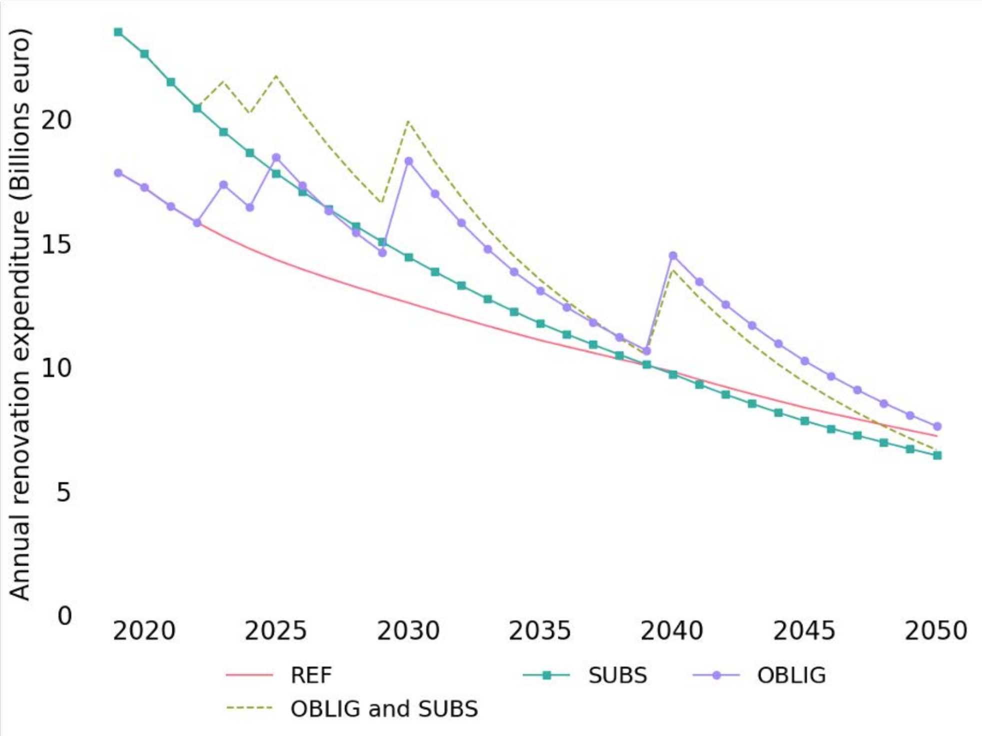


Fuel poverty assessed by number of households energy-to-income ratio (EIR) < 10%.

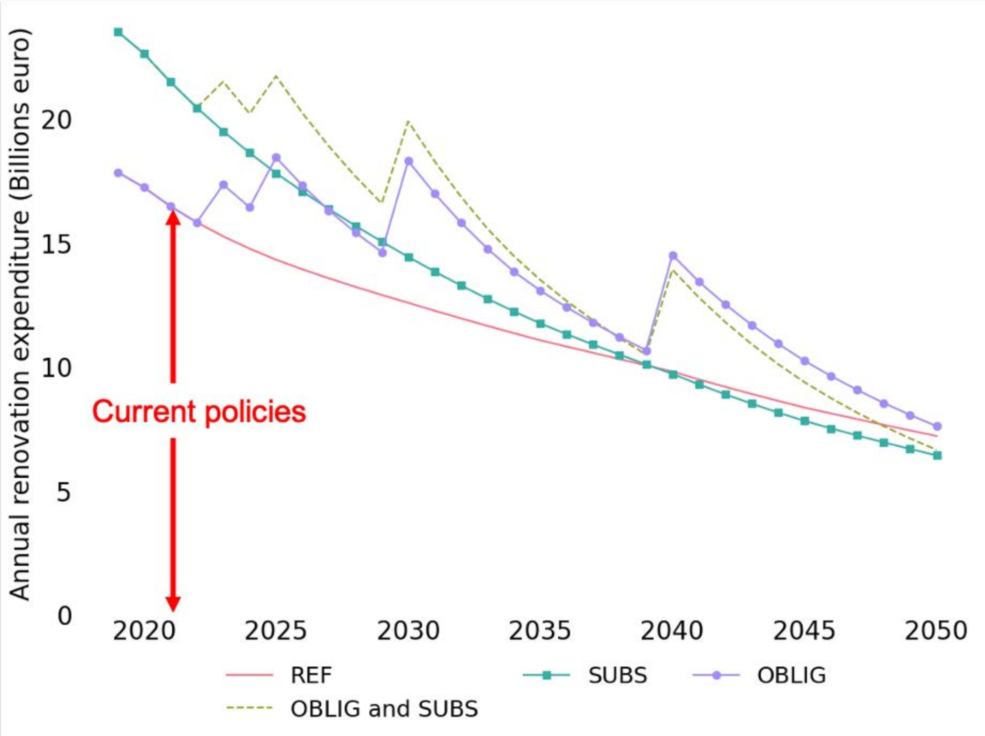
$$\text{EIR}_{n,t} = \frac{\text{Consump}_{n,t} \times \text{Price}_t}{\text{Income}_{n,t}}$$

200,000 households out of fuel poverty

Renovation expenditures

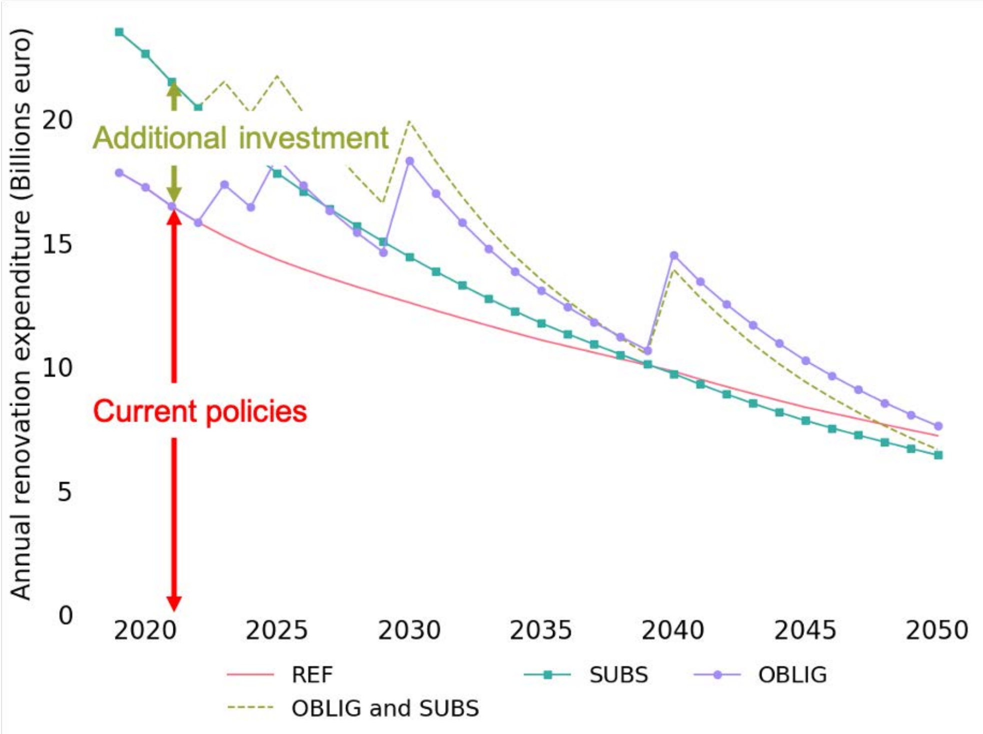


Renovation expenditures



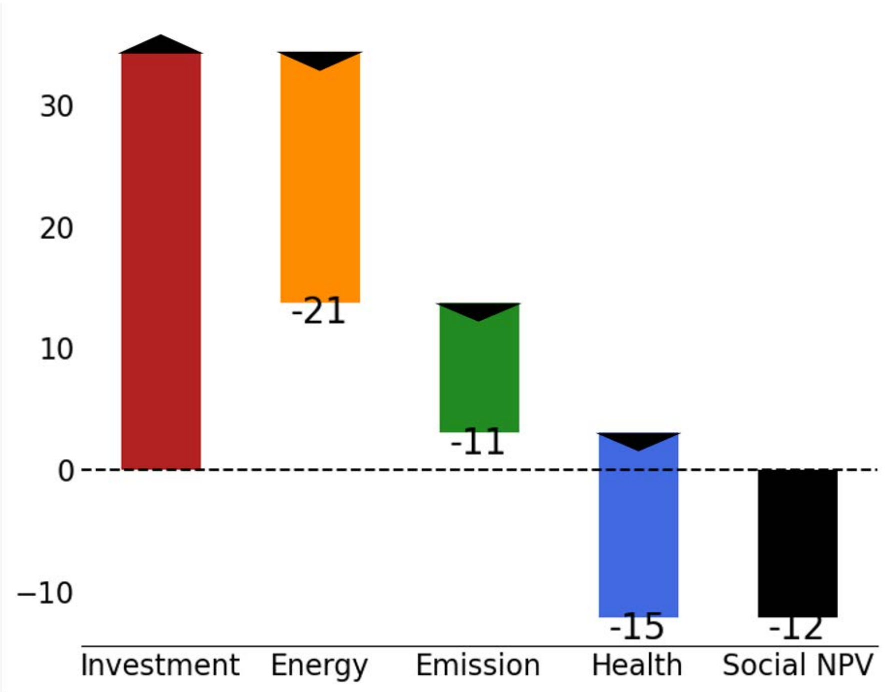
- Estimate consistent with the size of the French market for home energy retrofits, estimated to amount to 20 billion euros in 2019. (ADEME)

Renovation expenditures



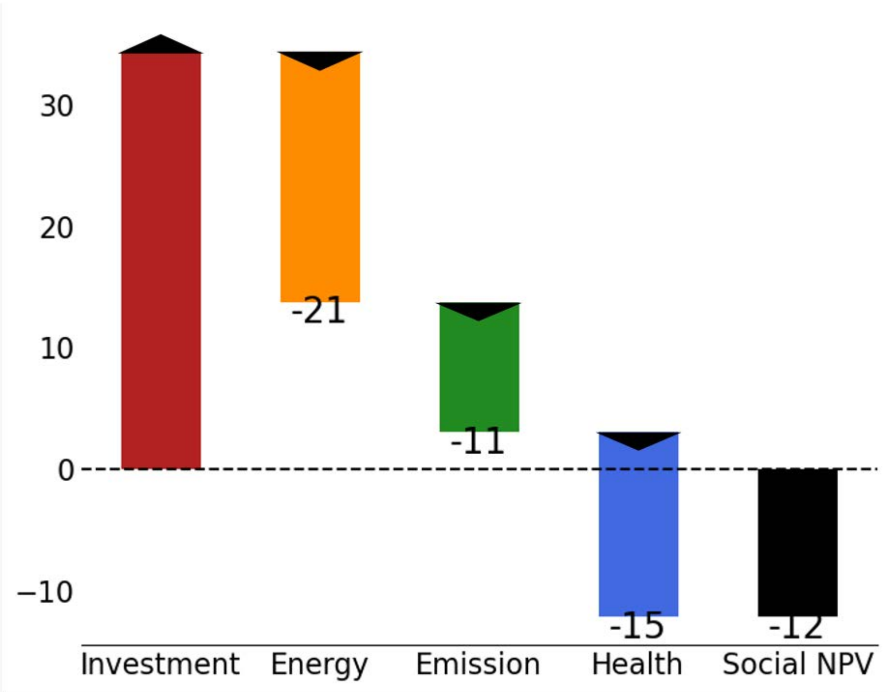
- Estimate consistent with the size of the French market for home energy retrofits, estimated to amount to 20 billion euros in 2019. (ADEME)
- Annual investment increases by 4 to 6 billion euros.

Retrofitting obligation assessment



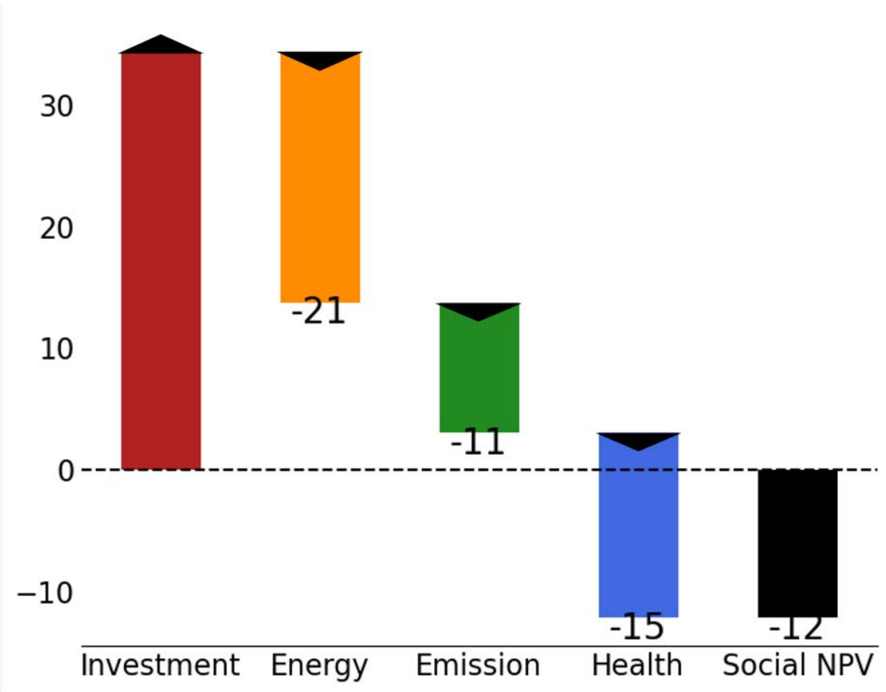
- NPV<0 indicates benefit.

Retrofitting obligation assessment



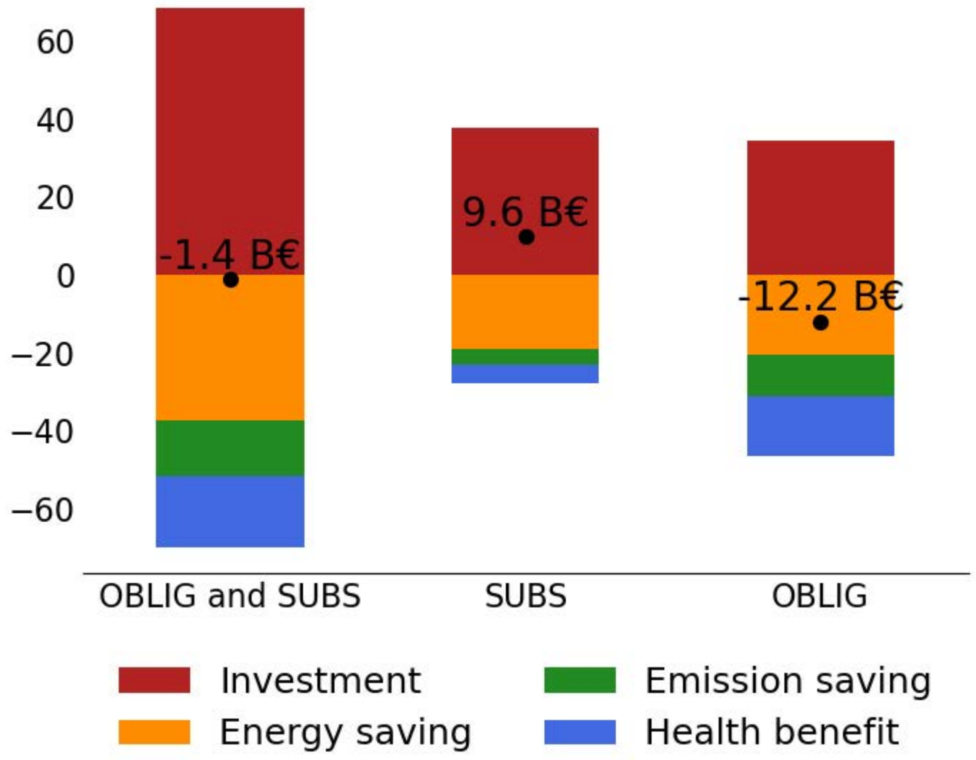
- NPV<0 indicates benefit.
- Investment - energy - emissions nearly break-even.

Retrofitting obligation assessment



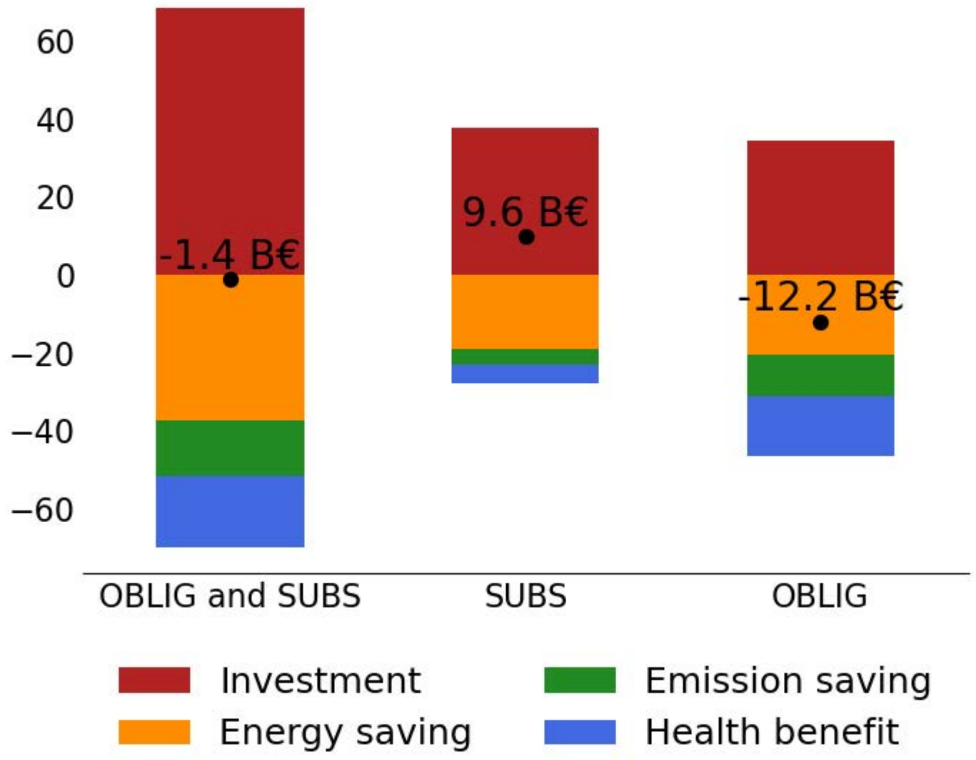
- NPV<0 indicates benefit.
- Investment - energy - emissions nearly break-even.
- Health improvement among tenants provides substantial extra benefits.

Retrofitting obligation assessment



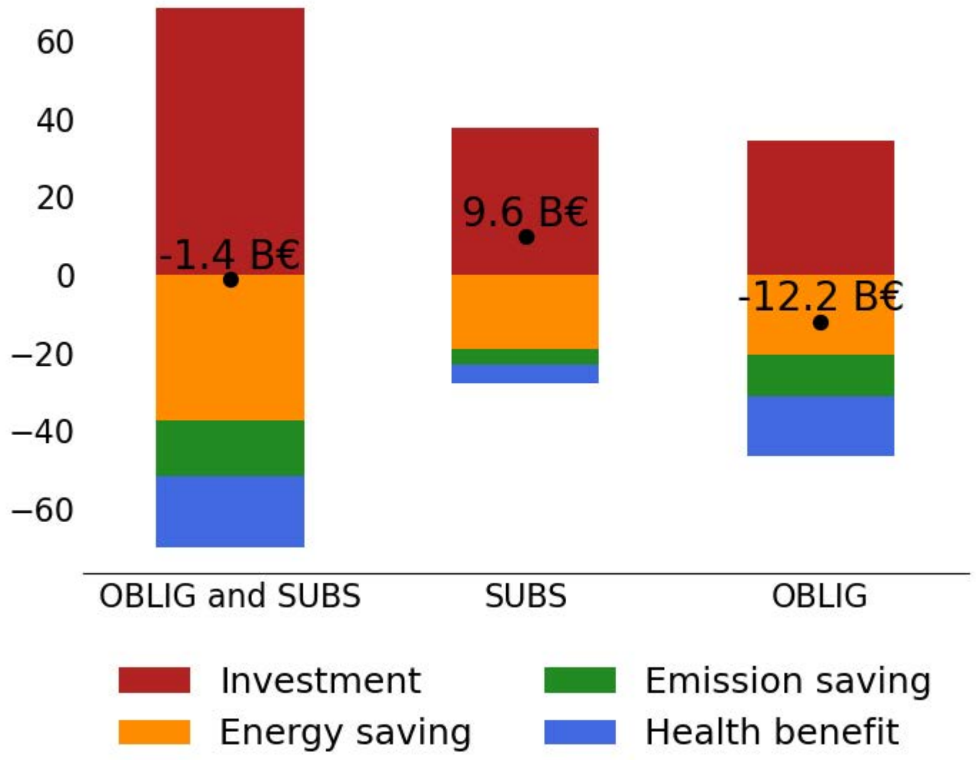
- The retrofitting obligation coupled with the CCC subsidy programme provides net benefits.

Retrofitting obligation assessment



- The retrofitting obligation coupled with the CCC subsidy programme provides net benefits.
- The proposed subsidy programmes could be counterproductive without the retrofitting obligation.

Retrofitting obligation assessment



- The retrofitting obligation coupled with the CCC subsidy programme provides net benefits.
- The proposed subsidy programmes could be counterproductive without the retrofitting obligation.
- Incentives only programmes miss some low-efficiency dwellings (rental).

Policies takeaway

1. **Specification considered**
   - Obligation based on stock turn-over (less blunt than true proposal).
   - Performance threshold: B (tighter than proposal).
   - Tightened over time (as proposed).
2. **Outcomes**
   - 200k more retrofits p.a.
   - Particularly effective at eliminating least-efficient dwelling in rental housing, thus reducing fuel poverty.
   - Extra cost: €6-8 billion p.a., including €3-5 in subsidies.
3. **The socio-economic balance is net positive**
   - Energy and environmental benefits nearly outweigh investment costs
   - Health benefits are substantial

Further research

Richer scenarios:

- Performance threshold: C, B or A.
- Blunt vs. turnover-based implementation.
- Endogenously-determined backup subsidy program.
- More sensitivity analysis.

Richer processes and market retroactions:

- Industrial bottlenecks
- Capitalization in real-estate markets
- Credit supply

Annex

Health cost

1. Health expenditures of the social security
2. The loss of well-being associated with the disease
3. The social cost of mortality
4. Does not take into account indirect costs

Households income		**Average health cost per household**		
Decile 1 to 3	Bellow poverty line	33,656 €	19,231 €	7,479 €
	Above poverty line	6,731 €		
Decile 4 to 10		421 €		

Table: *Source: (Dervaux and Rochaix, 2022)*

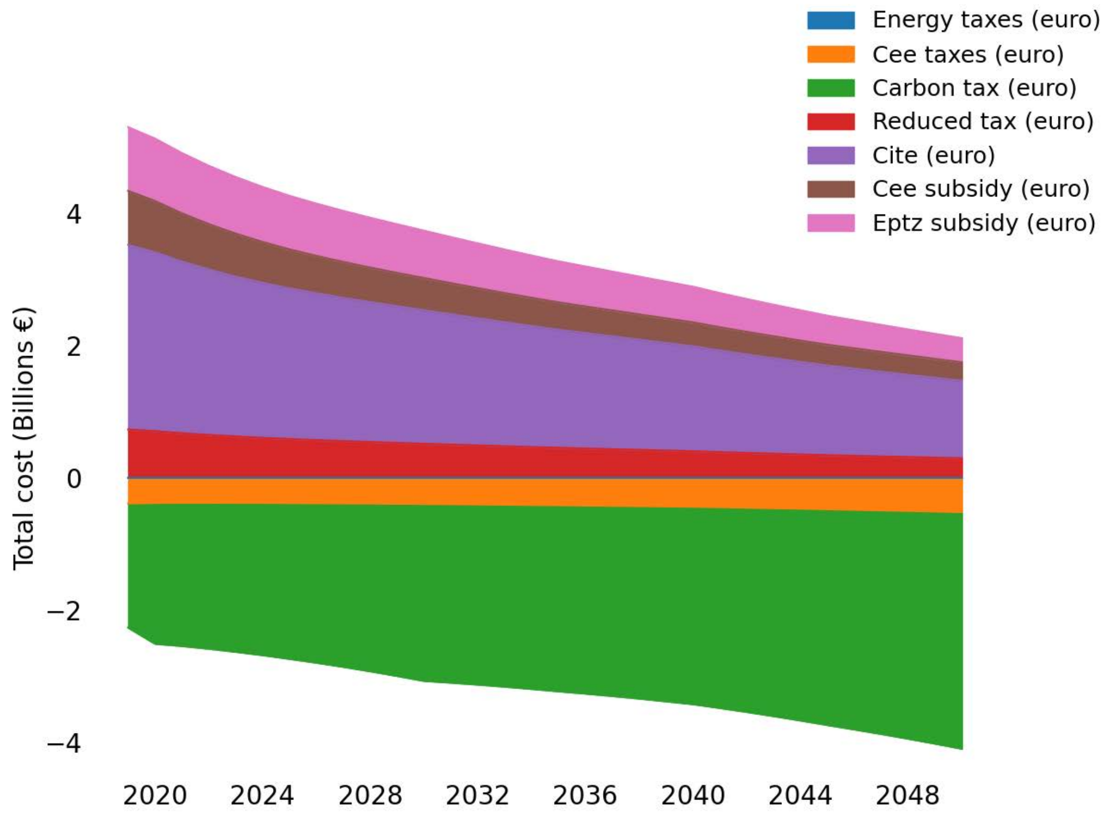


Figure: Policies expenditures (Billion €).

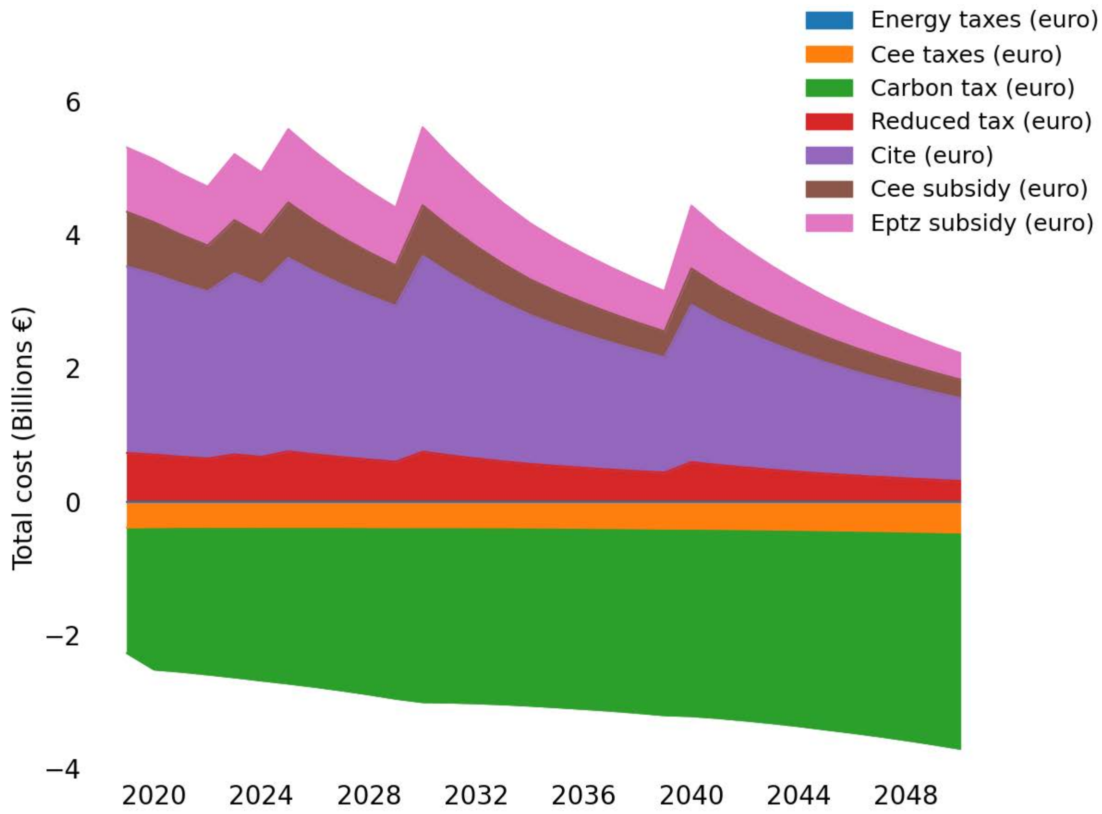


Figure: Policies expenditures (Billion €).

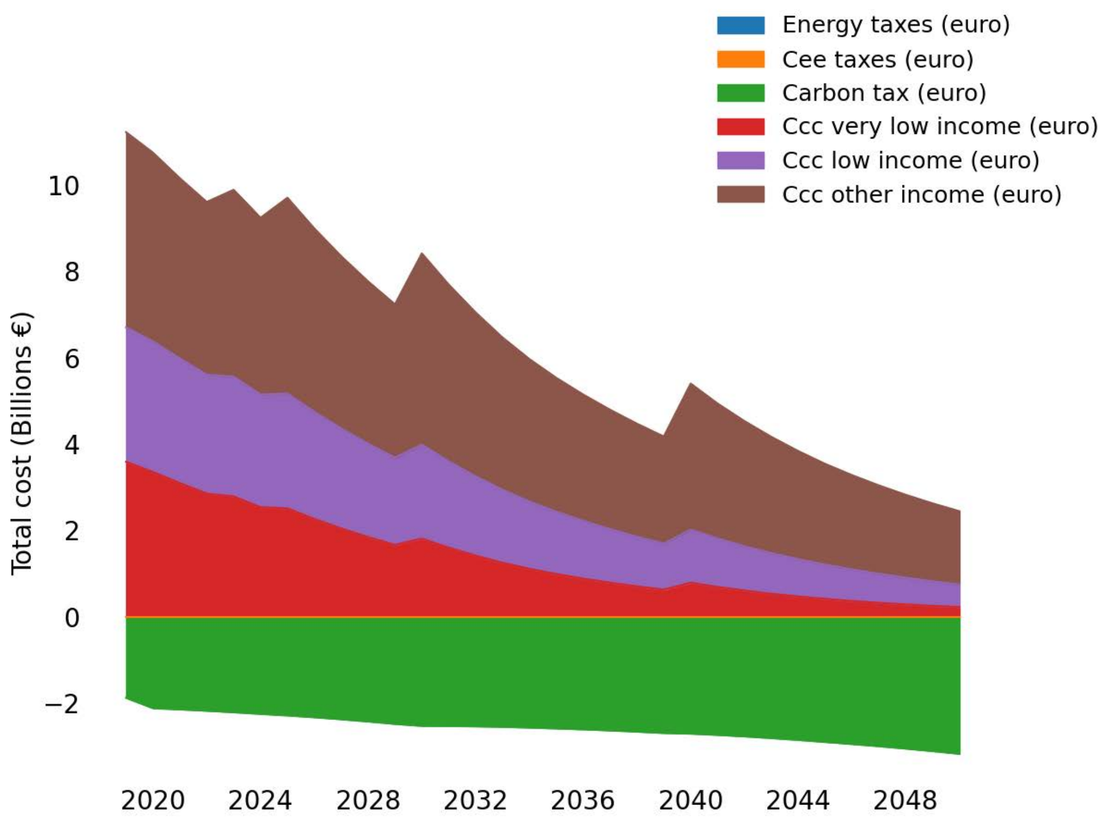


Figure: Policies expenditures (Billion €).

References

References I

Branger, Frédéric et al. (Aug. 2015). "Global sensitivity analysis of an energy–economy model of the residential building sector". en. In: *Environmental Modelling & Software* 70, pp. 45–54. ISSN: 1364-8152. DOI: 10.1016/j.envsoft.2015.03.021. URL: https://www.sciencedirect.com/science/article/pii/S1364815215001097 (visited on 02/22/2021).

Cabeza, L. F. et al. (2022). "Buildings". In: *IPCC, 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, UK and New York, NY, USA: Cambridge University Press.

Dervaux, Benoît and Lise Rochaix (Mar. 2022). *L'évaluation socioéconomique des effets de santé des projets d'investissement public*. fr. Tech. rep. URL: https://www.strategie.gouv.fr/publications/levaluation-socioeconomique-effets-de-sante-projets-dinvestissement-public-0 (visited on 05/24/2022).

Enertech et al. (Nov. 2021). *Perf in Mind*. Tech. rep. URL: https://www.effinergie.org/web/images/Page_PerfinMind/2020118_Synth%C3%A8se_et_r%C3%A9sum%C3%A9_1_pagev2_compressed.pdf (visited on 01/25/2022).

Eryzhenskiy, Ilya et al. (Feb. 2022). *Zero-Interest Green Loans and Home Energy Retrofits: Evidence from France*. en. DOI: 10/document. URL: https://hal-enpc.archives-ouvertes.fr/hal-03585110 (visited on 03/14/2022).

References II

Glotin, David et al. (Oct. 2019). "Prediction is difficult, even when it's about the past: A hindcast experiment using Res-IRF, an integrated energy-economy model". en. In: *Energy Economics*. Eighth Atlantic Workshop on Energy and Environmental Economics 84, p. 104452. ISSN: 0140-9883. DOI: 10.1016/j.eneco.2019.07.012. URL: https://www.sciencedirect.com/science/article/pii/S0140988319302336 (visited on 04/15/2021).

Nauleau, Marie-Laure (Nov. 2014). "Free-riding on tax credits for home insulation in France: An econometric assessment using panel data". en. In: *Energy Economics* 46, pp. 78–92. ISSN: 0140-9883. DOI: 10.1016/j.eneco.2014.08.011. URL: https://www.sciencedirect.com/science/article/pii/S0140988314001923 (visited on 12/21/2021).

Quinet, Alain (Feb. 2019). *La valeur de l'action pour le climat*. fr. Tech. rep., p. 190.

Risch, A. (2020). "Are environmental fiscal incentives effective in inducing energy-saving renovations? An econometric evaluation of the French energy tax credit". English. In: *Energy Economics* 90. ISSN: 0140-9883. DOI: 10.1016/j.eneco.2020.104831.

Vivier, Lucas (May 2022). *CIRED/Res-IRF: v3.1*. DOI: 10.5281/ZENODO.6553021. URL: https://zenodo.org/record/6553021 (visited on 05/22/2022).