

Research Project

Installers Response to Heat Pump Subsidies

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Abstract

This paper examines how heating firms in France responded to the heat-pump subsidy reforms implemented between 2018 and 2020. Using administrative data covering all French establishments and exploiting geographical variation in exposure to fuel-oil and gas heating, we identify the effects of these reforms on firms' decisions to obtain the RGE certification, a prerequisite for operating in the subsidized market. We combine difference-in-differences and event-study models to estimate the causal impact of the policy changes. Our findings reveal a strong contrast between the 2018 reform, which targeted low-income households and generated no significant response, and the 2019 reform, which expanded subsidies to all households and triggered a substantial increase in certification rates, particularly in areas with high fuel-oil dependence. These results highlight the importance of demand scale and market incentives for supply-side reactions. They pinpoint an efficiency-equity trade off. The paper contributes to the literature on energy-efficiency policies and offers insights for designing effective and just interventions to support the heating sector's role in the ecological transformation.

1 Introduction

Each winter, millions of households across Europe rely on fossil-fuel-based heating systems, contributing significantly to the continent’s greenhouse gas emissions. In the European residential sector, dependence on fossil fuels remains high: natural gas accounts for approximately 35% of final energy consumption, while electricity represents around 28% [1]. In this context, the electrification of heating through heat pumps is considered a key strategy to achieve carbon neutrality.

France occupies a particularly strategic position in this transformation. Its electricity system, largely supported by nuclear power, which accounts for more than 40% of the country’s total energy supply, and complemented by renewable sources, provides favorable conditions for the large-scale deployment of electric heating technologies [2]. In recent years, the French government has implemented programs such as MaPrimeRénov’ and the France Relance Plan, designed to promote energy efficiency and accelerate the replacement of gas boilers with cleaner technologies [3, 4, 5]. However, despite the scale of these initiatives, the French residential housing stock still presents substantial room for improvement: achieving carbon neutrality by 2050 will require sustaining and intensifying current efforts [6].

In the academic literature, energy economics has extensively documented the existence of the so-called energy efficiency gap, that is, the under-adoption of efficient technologies despite their profitability [7]. This phenomenon is attributed to a combination of market failures—such as information problems, financial barriers, and externalities—and behavioral factors, including giving excessive weight to upfront costs or not paying attention to available energy information [8, 9, 10]. In this context, several studies show that consumers respond incompletely to economic incentives or technical information, which supports the use of public policies such as minimum standards and subsidies [11, 12]. In the building sector, households cannot observe in advance either the quality of the renovation works or the actual energy savings these works will generate. This makes trust in installers and in certification systems a key element [13]. Moreover, recent studies show that the savings achieved after renovations are often lower than expected, and that a share of households would have undertaken these investments even without subsidies, which reduces the actual effectiveness of the programs [5, 14, 15]. In the French context, the literature has examined both the functioning of the Energy Savings Certificates system and the distributional effects of its obligations, highlighting the central role of installers in the effectiveness of these policies [13, 16].

However, there is still limited causal evidence on how public policies affect the behav-

ior of installation firms, which play a crucial role in the effective adoption of low-carbon technologies. A recent study by Wald [17] shows that a sudden increase in demand driven by subsidies can accelerate heat-pump adoption among installers and lead to significant changes in employment within the sector—such as the creation of new positions and the disappearance of others—although it does not specifically analyze the decision to obtain RGE certification.

This study contributes to filling this gap by examining how the subsidy reforms introduced between 2018 and 2020 changed the incentives for heating firms to obtain the RGE certification for heat pumps, which is required to operate in the subsidized market. To do so, we employ difference-in-differences and event study methodologies, which allow us to causally estimate the effect of these policies on installers' certification decisions. Following recent advances in settings with staggered adoption [18], we assess how these reforms affected the likelihood that firms obtained the RGE certification.

The remainder of the paper is structured as follows. Section 2 provides an overview of the policy background in France. Section 3 presents the data sources, construction of the treatment and control groups, and descriptive statistics. Section 4 outlines the empirical strategy, including the difference-in-differences and event-study approaches. Section 5 reports the main results. Finally, Section 6 discusses the implications of our findings and concludes.

2 Background on France's Energy Efficiency Policy

France's energy efficiency policy has evolved progressively since the mid-2000s, combining public instruments (subsidies, tax credits) with regulated private mechanisms, most notably the Energy Savings Certificates scheme (Certificats d'Économies d'Énergie, CEE) [19]. Under this system, energy suppliers are required to finance efficiency improvements, making the CEE one of the central pillars of the country's decarbonization strategy.

A key element of the French framework is the RGE certification (Reconnu Garant de l'Environnement), introduced in 2014 as an eligibility criterion for accessing various public subsidies aimed at financing energy renovation works [20, 21]. Its purpose is to ensure the quality of installations and to professionalize the sector, as documented by ADEME and the Ministry for the Ecological Transition [3]. However, French heating firms face several practical constraints that shape their decision to obtain the RGE certification. Becoming RGE-certified requires completing dedicated training modules, meeting technical quality standards, and paying registration and audit fees, which represent a non-negligible

investment for small firms [21]. At the same time, access to the subsidized heat-pump market depends on contextual factors such as household income, energy prices, building characteristics, and climatic conditions. Heat-pump installation remains costly—with average prices around €12,000 for an air-to-water system in 2021—while technical feasibility varies depending on insulation levels, heating distribution systems, and whether the dwelling is single-family or collective housing [5, 22, 23].

From 2018 onwards, France significantly strengthened its policy to electrify residential heating. The fourth phase of the CEE scheme began that year, doubling cumulative energy-saving targets and introducing, for the first time, a specific obligation benefiting low-income households. In this context, the government launched the “Coup de Pouce Chauffage” initiative in April 2018 to accelerate the replacement of oil-fired boilers with heat pumps through enhanced subsidies [24]. Vulnerable households could receive up to 3,000€, helping to reduce liquidity constraints and speed up the removal of highly polluting heating systems [16].

In January 2019, the program was expanded both in scope and amount. Subsidies became available to all households, with minimum amounts of 2,500€ for middle-income households and 4,000€ for low-income ones. Eligibility was also extended to the replacement of inefficient gas boilers. This reform positioned heat pumps at the center of France’s heating electrification strategy and generated a substantial increase in demand [24].

These policy changes had direct implications for installation firms. Since only RGE-certified companies can operate in the subsidized market, the combination of (i) the strengthened use of the certification from 2014, (ii) the targeted support introduced in 2018, and (iii) the large-scale expansion in 2019 significantly altered the economic incentives faced by heating firms. In practice, these reforms expanded the potential market for heat pumps and encouraged new firms to obtain certification, reshaping the structure and dynamics of the sector.

Taken together, this regulatory context, characterized by clearly identifiable policy shocks and a well-defined entry barrier, provides an ideal setting for analyzing how installation firms adjust their certification decisions in response to changes in economic incentives. This mechanism constitutes the core of our empirical analysis.

3 Data

We use six different datasets. These datasets are presented in the first subsection below. The second subsection details how we defined the control and the treatment groups for our Difference-in-Difference and Event Study models. The last subsection gathers descriptive statistics about the two groups.

3.1 Data sources

French 2017 population census. Provided by the French National Institute for Statistics and Economic Studies (INSEE), the 2017 population census [25] contains data on French housing units at the municipality level. The municipalities are those in effect on January 1, 2019. For each municipality, identified by its INSEE code, the database includes information on the main heating source of each household, with a weighting for representativeness. This dataset is used to link municipalities to their main heating sources.

SIRENE database. Provided by INSEE, the national comprehensive directory for the identification of French companies and their establishments [26] contains data about each French establishment, including geographical coordinates, main economic activity identified by a main activity code, and administrative status (whether it is active or closed). Two datasets of this database are used to know the history and spatial location of all French establishments in the 2017-2020 time period.

Register of certified contractors. Provided by the French Energy Management Agency (ADEME), the register of certified contractors [27] lists the history of all RGE-certified establishments since 2014. Building professionals specializing in energy renovation work or the installation of equipment using renewable energy can obtain one or more RGE (Recognized Environmental Guarantor) labels. These labels allow them to showcase their expertise, offer a guaranty of quality to their clients, and be referenced. Certified establishments also allow their clients to benefit from financial assistance (tax credit, MaPrimeRénov', zero-interest eco loan, etc.) for their energy retrofit projects [28]. Among those RGE certifications, some allow access to the market for subsidized heat pump installations : *thermodynamic water heater, heat pump : heating and heat pump and/or thermodynamic water heater 2020*. These RGE-certifications for heat pump installation serve as a proxy for heating firms response to 2018-2020 public policies.

Activity codes classifications. Provided by (INSEE), the different activity codes and their classifications over time [29][30][31][32] link each activity code to an understandable

work activity. The choice of work activities which could possibly lead to RGE-certification is critical to define the control group of the econometric models.

French administrative municipalities, 1st January 2019. Provided by the French Water Information System, the French administrative municipalities ESRI Shapefile [33] is used to visualize all French municipalities in effect on January 1, 2019 in a Geographic Information System (GIS) such as the free and open-source QGIS. We used this file in QGIS to obtain spatial information about each French municipality.

Median income level per municipality, 2021. Provided by INSEE, the dataset [34] combines the median income level per French municipality. It is used for descriptive statistics only.

3.2 Defining control and treatment groups

We want to run a Difference-in-Difference analysis and an Event Study model to evaluate the effects of the public policies concerning heat pump installation on heating firms, during the January 2017 - March 2020 time period. To do so, we want to define the control group as establishments which could have become RGE-certified due to the policies but never were, and the treatment group as establishments that got RGE-certified during the time period. But what is an establishment which could have become RGE-certified due to the policies? We answer to this question by plotting the top 10 economic activity of certified establishments (see figures 3 and 4 in Appendix B). The top 3 accounts for more than 90% of all certified establishments. Establishments declaring one of these three economic activities are thus the most likely to ask for RGE-certification, as described more exhaustively in Appendix B. Consequently, we define the control and the treated group for our econometric models as follows :

- Control group : all establishments inactive less than 6 months between January 2017 and March 2020 with one of the three main economic activity of RGE-certified establishments, with their coordinates written in the national comprehensive directory of establishments, which were active on February 1, 2017 and which were never RGE-certified from January 1, 2017 and March 15, 2020. We get 109,390 unique establishments for this group.
- Treated group : all establishments with the same features as the establishments in the control group except the one about RGE-certification. Treated establishments were RGE-certified at least one month between January 2017 and March 2020. We get 7,524 unique establishments for this group.

3.3 Descriptive analyses

Table 1: Descriptive statistics for each group

	Control group		Treated group		Difference
	Mean	SE	Mean	SE	(C-T)
Number of unique establishments	109,390		7524		
Mean Population (in millions)	1.68	(2.65)	0.420	(1.04)	1.26
Mean median income level (in k€)	25.1	(2.31)	24.0	(2.27)	1.1
	Number	%	Number	%	(C-T)%
Housing type (TYPL)					
1 : detached house	75,307	68.8	6,419	85.3	-16.5
2 : flat	33,178	30.3	1,064	14.1	16.2
3-6 : other	905	0.9	41	0.6	0.3
Main fuel type of the housing (CMBL)					
2 : mains gas	32,051	29.3	1,279	17.0	12.3
3 : fuel oil	14,877	13.6	1,457	19.4	-5.8
1,4-6 : other	62,462	57.1	4,788	63.6	-6.5

Note : The table shows summary statistics for control and treated establishments on January 2017 (median income aside). Treated establishments are those that adopt heat pump certification during the 2017-2020 time period. Control establishments never adopt. SE stands for Standard Error. All statistics were calculated considering a 20 kilometers buffer around each establishment. For instance, **Mean Population** was obtained by considering all households in municipalities within a 20km zone around each establishment, averaging by using the number of establishments of each group.

Table 1 above shows descriptive statistics for the control and the treated groups. For each establishment in the control group and in the treated group, we considered a 20km buffer and collected data about the municipalities whose centroid is in the buffer. The French 2017 population census and the 2021 median income file give access to interesting data. On average, areas where establishments got certified are four times less populated, slightly poorer, and less unequal than areas where establishments do not get RGE-certified. The housing type and main fuel type of the two types of area differ as well : on average there are more detached houses, more oil and less mains gas in treated areas than in non-treated ones. Just like the statistics shown in table 4 (see Appendice C), table 1 suggests RGE-certified establishments are in more rural areas than non-certified

ones on average. It is also consistent with the fact that heat pumps are a viable alternative to fossil-fuel boilers in detached houses but not for all collective housings [5]. We leverage the local heterogeneity of main fuel type as a proxy for the type of area.

4 Empirical Strategy

To investigate the effects of the 2018 and 2019 policies, we need a way to bridge demand and supply : establishments will adopt the RGE-certification for heat pumps if there is a surge in demand for the technology.

4.1 The bridge between supply and demand

The French government website. In 2018, as subsidies were introduced for low-income households to help them achieve their energy retrofit projects, the French government created a search engine to help households find certified contractors. One could input a municipality and the type of work needed, and the search engine listed all certified contractors within a certain radius, ranked by Euclidean distance from the municipality centroid to the contractor's location. 20km was a possible radius. Figures 5a and 5b (Appendix D) show the website interface.

Defining an establishment level exposure. We leverage this distinctive feature to define an establishment-level exposure to the policy-induced increase in demand for heat pumps. Since the subsidy was made conditional on the replacement of fuel oil boilers (as of January 2018) and gas boilers (as of January 2019), we calculate a rank-weighted average of fuel oil (and gas) penetration rates across all municipalities located within a 20 km radius of each establishment, thereby replicating the ranking system used on the government website (see figure 6 in Appendix E). The mathematical formulation of the penetration rate is detailed in Appendix E and can be adapted to assess exposure to gas or to fossil fuels more broadly by aggregating oil and gas data. In a nutshell, for oil exposure, the greater the number of housing units heated by fuel oil in the municipalities surrounding a given establishment, the higher the establishment's exposure to oil. Furthermore, proximity to municipalities with high levels of oil heating intensifies this exposure. Figure 7 in Appendix E shows oil exposure in France. It is consistent with descriptive statistics above : high exposure can be found in rural areas, while there is a low exposure to fuel oil in large cities on average. With fuel oil exposure being defined, we do the same for gas and we can move to the econometric models. Descriptive statistics of exposure measures can be found in table 5 (Appendix E).

4.2 Difference-in-Difference models

First, we compute a Difference-in-Difference analysis, capturing the average effect of fossil fuel exposure on RGE certification after January and June 2019.

Fossil fuel DiD. We consider the following model :

$$Y_{it} = \alpha_i + \lambda_t + \beta \times \mathbb{1}_{t \geq \text{Jan.2019}} \times E_{FF,i} + \epsilon_{it} \quad (1)$$

where Y_{it} is a binary variable for RGE certification of establishment i in month t (0 if not certified, 1 otherwise), α_i is the establishment fixed effect, λ_t is the month fixed effect, $E_{FF,i}$ is the exposure measure for establishment i (here FF means fossil fuel : oil and gas together). ϵ_{it} is the error term. The establishment fixed effect accounts for local particularities (climate, type of housing...), while the month fixed effect accounts for mean monthly variations across all establishments. We compute this model for two different reference dates : January 2019 and June 2019.

Separate fuel DiD. Policy implementation was staggered in time : in January 2018, subsidies were directed to low-income households for replacing oil boilers only, while in January 2019 subsidies were extended to all households for replacing oil and gas boilers. Moreover, it is not the same type of area where people have fuel oil boilers and gas boilers (urban vs rural areas). Thus, it is relevant to separate the effect of oil exposure and the one of gas exposure on RGE-certification using the following model :

$$Y_{it} = \alpha_i + \lambda_t + \beta_{Oil} \times \mathbb{1}_{t \geq \text{Jan.2019}} \times E_{Oil,i} + \beta_{Gas} \times \mathbb{1}_{t \geq \text{Jan.2019}} \times E_{Gas,i} + \epsilon_{it} \quad (2)$$

where $E_{Oil,i}$ is the exposure measure for establishment i for fuel oil, and $E_{Gas,i}$ is the exposure measure for establishment i for natural gas. Just like the Difference-in-Difference analysis for fossil fuels above, we compute the analysis for both January 2019 and June 2019.

4.3 Event Study model

The event study model allows for an estimation of the fuel oil and gas effect on RGE-certification across time. The model is relevant to study the timing of the heating firms response to the surge in demand for heat pumps. We use the following model :

$$Y_{it} = \alpha_i + \lambda_t + \sum_{\tau=-14}^{20} \beta_{\tau} \times \mathbb{1}_{t=\text{April } 2018+\tau} \times E_{Oil,i} + \sum_{\tau=-14}^{20} \gamma_{\tau} \times \mathbb{1}_{t=\text{April } 2018+\tau} \times E_{Gas,i} + \epsilon_{it} \quad (3)$$

where τ indexes months relative to April 2018 ($\tau \neq -1$). We chose April 2018 because it is the month of implementation of the low-income policy. The fact that we account for natural gas separately is also a form of robustness test : we will see if there is a delay between policy implementation and heating firms reaction.

5 Results

5.1 Difference-in-Difference analysis

Simple DiD model First, we compute regression (1). We choose to run the regression with a cluster-robust covariance estimator because the mean Durbin-Watson statistic amounts to 0.0373 and thus reveals residuals for a same establishment are highly positively autocorrelated across time. We discuss further of this so-called serial correlation problem (see 6.2), and we cluster at the establishment level. We do not run the regression for a homoskedastic covariance estimator because it is clear that the variance of the error depends on the exposure : for extreme exposure values, it will be smaller than for average values. Results are shown in table 2 below.

Table 2: Results of the Difference-in-Difference analysis for two reference dates

Reference date	Estimation 1		Estimation 2	
	1st January 2019		1st June 2019	
Variables	Coefficient	Std error	Coefficient	Std error
Post reference date period				
β	0.0052*	(0.027)	0.0049*	(0.029)
Entities	116,914			
Time periods	39			
Number of observations	4,559,646			
R-squared (adjusted)	0.000014		0.000010	
R-squared (within)	0.0008		0.0008	

Note : This table examines the results of regression 1 with two different threshold dates (January and June 2019). Results are significant at a 10% level. Standard errors are robust and clustered by establishments. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

We see that β does not vary much between January and June 2019. What is more, β is positive : the higher the fossil fuel exposure, the higher the probability of being RGE-certified. On average, after January 2019, if fossil fuel exposure increases by 10% of its maximum possible change (10% of $0.882 - 0.033 = 0.849$, see table 5 in Appendix E), the probability of being RGE-certified increases by $0.0849 \times 0.0052 = 0.044\%$. Even if the result is not particularly impressive, it is consistent with the main objective of the policies, that is to say encouraging the replacement of fossil fuel boilers by heat pumps.

However, as of now, we do not know if oil exposure contributed more to heat-pump certification than gas exposure, if there was a delay between policy implementation and

reaction of the supply side, and if both the 2018 and the 2019 policies bore fruit. Separating fuel types would help answering the first question. Using an event study model over the 2017-2020 period would help answering all of them.

Separate fuel type DiD model Thus, we compute regression (2) with the same cluster-robust covariance estimator as for regression (1). Results are shown in 3 below.

Table 3: Results of the Difference-in-Difference analysis for two reference dates

Reference date	Estimation 1		Estimation 2	
	1st January 2019		1st June 2019	
Variables	Coefficient	Std error	Coefficient	Std error
Post reference date period				
β_{Oil}	0.069***	(0.0061)	0.094***	(0.0066)
β_{Gas}	0.015***	(0.0028)	0.019***	(0.0030)
Entities	116,914			
Time periods	39			
Number of observations	4,559,646			
R-squared (adjusted)	0.0007		0.0010	
R-squared (within)	-0.0003		-0.0001	

Note : This table examines the results of regression (2) with two different threshold dates (January and June 2019). Results are significant at a 1% level. Standard errors are robust and clustered by establishments. *** p<0.01, ** p<0.05, * p<0.1.

We see β coefficients are still positive which is consistent with the goal of the policies. Interestingly, we see that oil exposure has a far larger effect on RGE certification than gas exposure in January and June 2019. On average, in June 2019, if oil exposure increases by 10% of its maximum possible change (10% of 0.516, see table 5 in Appendix E), the probability of being RGE-certified increases by $0.094 \times 0.0516 = 0.49\%$. If gas exposure increases by 10% of its maximum possible change (10% of 0.848, see table 5), the probability of being RGE-certified increases by $0.019 \times 0.0848 = 0.16\%$. Thus, it is oil boiler replacement that mainly drives the increase in heat-pump certification.

Conducting the event study detailed in regression (3) will give more information about the policy effects and timing. Keeping gas apart from oil is a key feature toward understanding if there is a delay between policy implementation and reaction of heating firms.

5.2 Separate fuel type Event study

The event study model (3) estimates the effect of oil and gas exposure for each month between January 2017 and March 2020. We take a covariance estimator clustered at the establishment level. The coefficients (β_τ) capture the dynamic effect of fuel oil exposure on the probability of obtaining an RGE certification over time, with 95% confidence intervals. Same can be said for (γ_τ) coefficients regarding gas exposure. Results are shown in figures 1 and 2 below.

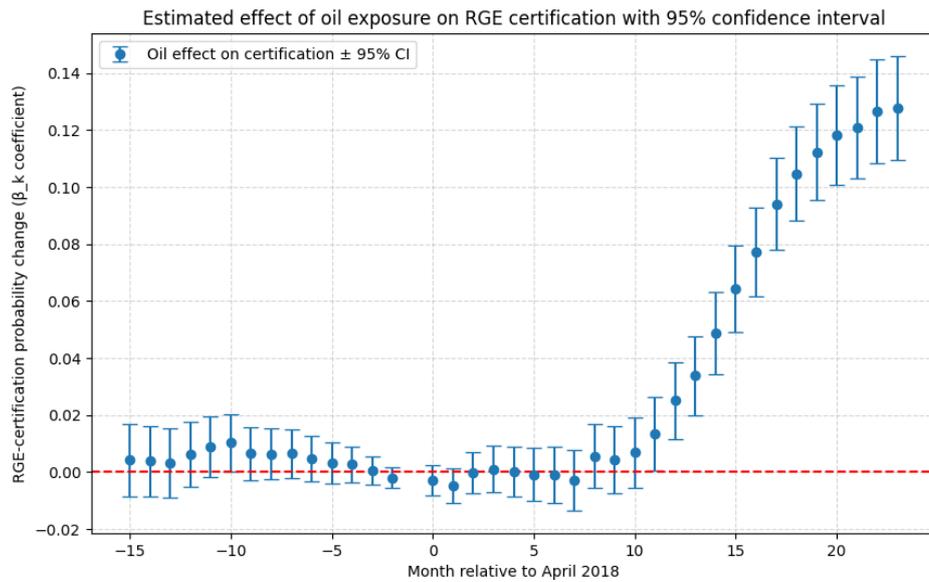


Figure 1: Event study model results (oil)

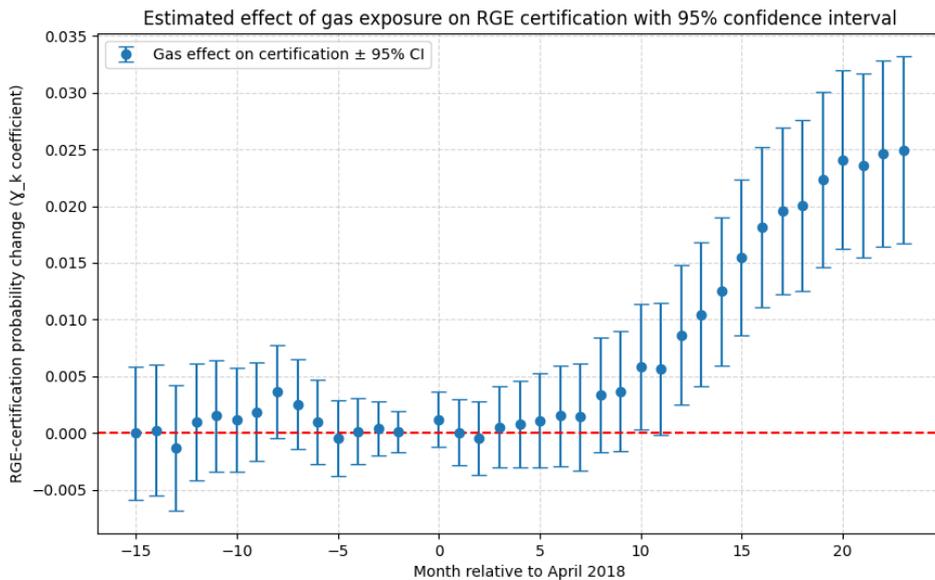


Figure 2: Event study model results (gas)

The results are stunning : the effect of oil exposure on the probability of certification is null before the 2019 policy implementation, while the low-income policy was implemented in April 2018. More precisely,

- Before January 2019 ($\tau \leq 9$), the estimated effect of both oil and gas exposure fluctuates around zero, indicating the absence of differentiated pre-trends and suggesting that, prior to the implementation of the 2019 policy, firms exposed to fuel oil and gas and those in the control group followed similar trajectories. It is good to note that between December and January 2019 ($8 \leq \tau \leq 9$), the effect of gas exposure begins slowly to increase even if the results are not significant, perhaps suggesting anticipation by heating firms.
- Around January 2019 ($8 \leq \tau \leq 10$), which coincides with the introduction of the new subsidy scheme, the coefficients remain close to zero, showing no visible effect yet. This suggests that the policy did not have an immediate impact on firms' behavior, and it is consistent with the need for an adaptation period, during which firms may have required time to gather information, adjust their strategies, or complete the administrative procedures necessary for obtaining RGE certification. The fact that we did all the estimations considering the first of each month can also explain this result.
- From March 2019 onward ($\tau \geq 11$), the coefficients begin to increase progressively and significantly, indicating that firms exposed to fuel oil and gas started to respond to the new public incentives. Using the vertical scale, we can confirm that the effect of oil exposure on the RGE-certification probability is much larger than the effect of gas exposure throughout the time period. More interestingly, the effect of gas exposure on the certification probability becomes significant in February - March 2019. This implies that there is not a large delay between policy implementation and the reaction of heating firms. Thus, the takeoff we see concerning oil, which begins in March 2019, is the result of the 2019 policy and not the delayed response to the April 2018 policy. With this in mind, the gas takeoff acts as a robustness check for oil.

6 Discussion and Policy Implications

6.1 Discussion about the results

First, we need to explain the striking null result of oil exposure on RGE-certification in 2018, since apparently the April 2018 policy which targeted low-income people only did not produce the desired effect. The main reason is likely that the entry into the RGE contractor market requires a critical mass (broad-based demand rather than targeted eligibility) to become interesting. The demand for heat pumps probably did not increase significantly after April 2018. Various reasons could explain this result. First, the subsidy likely produced a pass-through effect on the prices of heat-pumps, making them more expensive. In addition, information about the subsidy may not have been broadly accessible because the policy affected the poorest only. Hazy administrative procedures also put a brake to heat-pump demand. Finally and most probably, the 2,000\$ or 3,000\$ subsidy may not have been sufficient at all to generate enough demand for heat pumps. Indeed, 3,000\$ is about a quarter of the average upfront cost needed to buy and install a heat pump in 2020 [22].

It is only when subsidies become accessible to anyone, regardless of the income, that oil and gas exposure begin having an increasing and significant effect on RGE-certification. The subsidy, despite being small compared to the high upfront cost, likely acted as a trigger for wealthy households that could afford the large majority of the upfront costs and just needed a good reason to switch to heat pumps.

We thus recognize an efficiency - equity tradeoff : subsidizing the wealthiest triggers energy retrofit projects, leading firms to adopt RGE-certification. At the same time, the pass-through effect increases the price of heat-pump installation, and public money increases inequalities. There is no reason that low-income people benefited from the policy because the number of RGE certified contractors was most probably not the limiting factor. To make sure of that, we think there is a great need for a comprehensive assessment of the effects of the policies on low-income households. Precisely understanding which type of household benefited from the policies is key to improve them.

6.2 Discussion about hypothesis and robustness

The models we used rely on multiple hypothesis. Choices were made and need to be presented [18].

On the choice of a linear probability model. In all the study, we used linear probability models because the outcome variable is a binary variable (an establishment is

certified or not). We chose linear models because it is the norm. However, there is likely a threshold effect : if the exposure is sufficiently little, it is unlikely that there would be any establishments adopting RGE-certification. Similarly, if exposure is sufficiently large, it is likely that RGE-certification becomes a key asset to have for any heating firm. Quantifying this threshold effect could be interesting to improve public policies. We leave it to future research.

On the models underlying hypothesis. Some hypothesis underlying the models we used may have not been verified. These hypothesis are the following :

- The conditional mean assumption states that $\mathbb{E}(\epsilon_{it}|\alpha_i, \lambda_t, S_{FF,i}, \mathbb{1}_{t \geq Jan.2019}) = \mathbb{E}(\epsilon_{it})$. However, the average error is likely to vary with exposure : with extreme exposure values, the average error would likely be smaller than with average exposure values.
- The error must not be auto-correlated : $Cov(\epsilon_{it}, \epsilon_{il}) = 0$ for $t \neq l$. This is clearly false because we computed Durbin-Watson statistics and saw that the residuals were significantly positively auto-correlated. We take this into account by using clustered-robust standard errors, as explained in the following paragraph. However, by using clustered standard errors, we assume that the errors are uncorrelated across separate establishment, which is questionable because there may very well be some correlation in the decision of adopting or not since some establishments share a same local context. There may also be some kind of technology diffusion on a local level, the RGE-certification becoming a must-have to increase (or keep) market shares. Ideas to take this effect into account are discussed in a paragraph below tackling spatial correlation.

On the choice of the covariance estimator. Since we used linear probability models, we need to account for heteroskedasticity. That is why we only computed heteroskedastic covariance estimators in our models. However, in panel data, the regression error can be correlated over time within an entity (here within an establishment). This effect is known as the serial correlation effect : what happens one month tends to be correlated with what happens the next month. Like heteroskedasticity, this correlation does not introduce bias into the fixed effects estimator but affects the variance of the fixed effects estimator, and therefore how one computes standard errors. The heteroskedasticity and autocorrelation robust (HAR) standard errors, also known as clustered standard errors, can be used to take this effect into account. They allow for heteroskedasticity and for arbitrary autocorrelation within a cluster, but treat the errors as uncorrelated across separate clusters. Since errors are highly autocorrelated within an establishment over time (as shown by the computation of mean Durbin-Watson statistics), clusters can be

defined at the establishment level [18]. The error computed with this method will be accurate thanks to the large number of clusters (116,914 establishments) [18, 35, 36].

On the spatial correlation problem. All models were computed using cluster-robust standard errors. The blind spot lies in the fact that we assume that the clusters are independent from one another and thus that errors are uncorrelated across separate establishments [18][36]. Indeed, if a heating firm adopts RGE-certification in a certain town, it is very likely it gains market share on the others that do not adopt the certification : the certified establishment will be able to access the subsidized market and advertise on its brand new certification. Hence, we need to account for spatial autocorrelation. What is more, since nearby establishments share about the same market, they share a same socioeconomic context and their choice of adopting the certification or not depends on this shared context. Thereby, taking into account the distance between establishments for computing standard errors seems very relevant. To do it, one could use the Conley standard error method [18]. Accounting for the serial correlation problem within entities and simultaneously for the spatial correlation problem across entities is left to future research.

7 Conclusion and Future Research Directions

This study examines how heating installers in France reacted to the heat pump subsidy reforms implemented between 2018 and 2020. Using administrative data and employing difference-in-differences and event-study models, we evaluate the extent to which changes in economic incentives encouraged firms to obtain the RGE certification, a mandatory requirement to operate in the subsidized energy-efficiency market.

The results reveal a clear asymmetry between the 2018 and 2019 reforms. The 2018 reform, which targeted only low-income households, did not generate a significant reaction from installation firms. Its limited scale, administrative barriers, and the inability of vulnerable households to cover upfront costs could explain the absence of effects. In contrast, the 2019 reform, expanding subsidies to all income groups and including the replacement of gas boilers, triggered a strong demand shock that substantially increased the adoption of RGE certification, especially in rural areas and those dependent on fuel oil. This response confirms the existence of a critical size needed for supply to react to public incentives. However, these benefits come with important tensions between efficiency and equity. Households with greater financial capacity were the main beneficiaries, while it remains unclear whether vulnerable households were truly able to make use of the subsidies. This highlights the need to redesign policies to prevent the ecological transfor-

mation from reinforcing existing inequalities.

Based on these findings, several avenues for future research emerge. First, more detailed information on household income would be necessary to accurately assess the distributional impact of the subsidies. Low-income households have the least room for maneuver and it is reasonable to think that they should benefit first from public policies. Second, policies should be complemented with technical training and effective replacement mechanisms that prevent practices such as the resale of used boilers (see figure 8 in appendix F), which undermine the environmental impact of the program. Finally, future work could analyze the actual energy consumption of households, by comparing consumption before and after the installation of heat pump, including potential rebound effects [7], especially since the history of energy is much more a story of addition than of substitution [37].

Overall, this study shows that subsidies can accelerate the technological transformation, but also highlights the importance of integrating equity considerations into the design of public policies to ensure a fair and effective ecological transformation.

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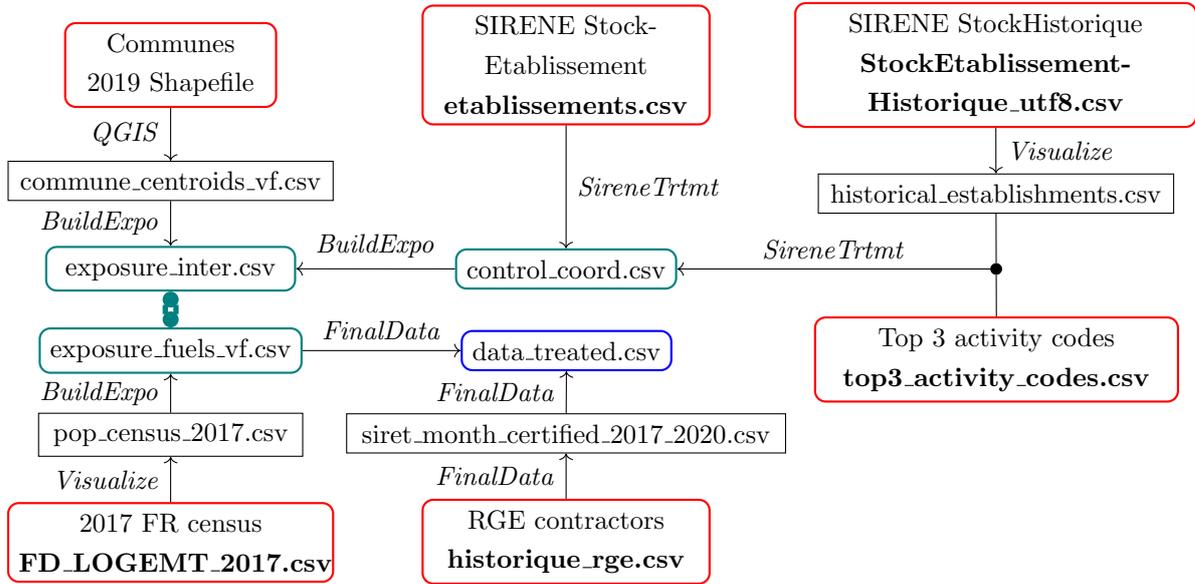
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Appendix

Appendix A : Data combination

Below is a graph recapitulating data combination across the different python files we used. Each python file name where the data combination took place is written next to the appropriate arrow. Raw data mentioned in 3 stands in red rectangles while the final data for econometric models stand in the blue rectangle. Green rectangles gather intermediate data obtained by merging different files. For sake of simplicity, we only represented the way we obtained the main data file **data_treated.csv**.



To be more specific, **population_census_2017.csv** (**pop_census_2017.csv** in the tree graph above) and **historical_establishments.csv** were obtained in **Visualize.ipynb** by choosing certain specific columns (see python files for more details). **control_coord** was obtained by selecting only establishments inactive less than 182 days (six months) between January 1, 2017 and March 15, 2020 (1), active on February 1, 2017 (2), having declared a main activity among the three selected in **top3_activity_codes.csv** during their history (3) and which Lambert 93 coordinates could be found in **etablisements.csv** (4). The establishments combining those four characteristics are called establishments of interest. They will be part either of the control group or the treated group in our models. To build the files **exposure_inter.csv** and **exposure_fuels_vf.csv**, we combined data about French municipalities and establishments of interest with geographical data about people leaving in the nearby municipalities of each establishments. Thus, we are able to compute the exposure (defined in section 4) for each establishment of interest. Finally, using data about RGE certified contractors, we build a matrix of zeros and ones informing if a specific establishment was RGE-certified during the time period.

Appendix B : Defining the control and the treatment groups

On figures 3 and 4 below, we plotted the number of certified establishments sharing a same main activity code (a same economic activity) on January 1, 2017 and January 1, 2020.

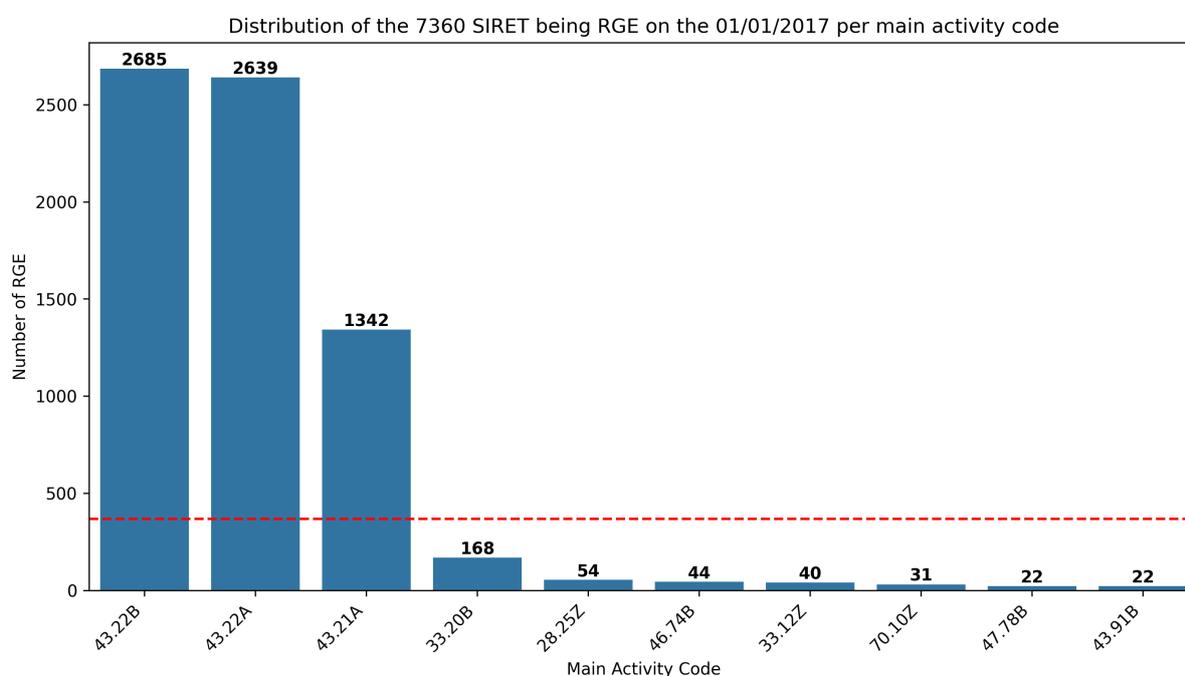


Figure 3: Number of unique RGE establishments per main activity code (01/01/2017)

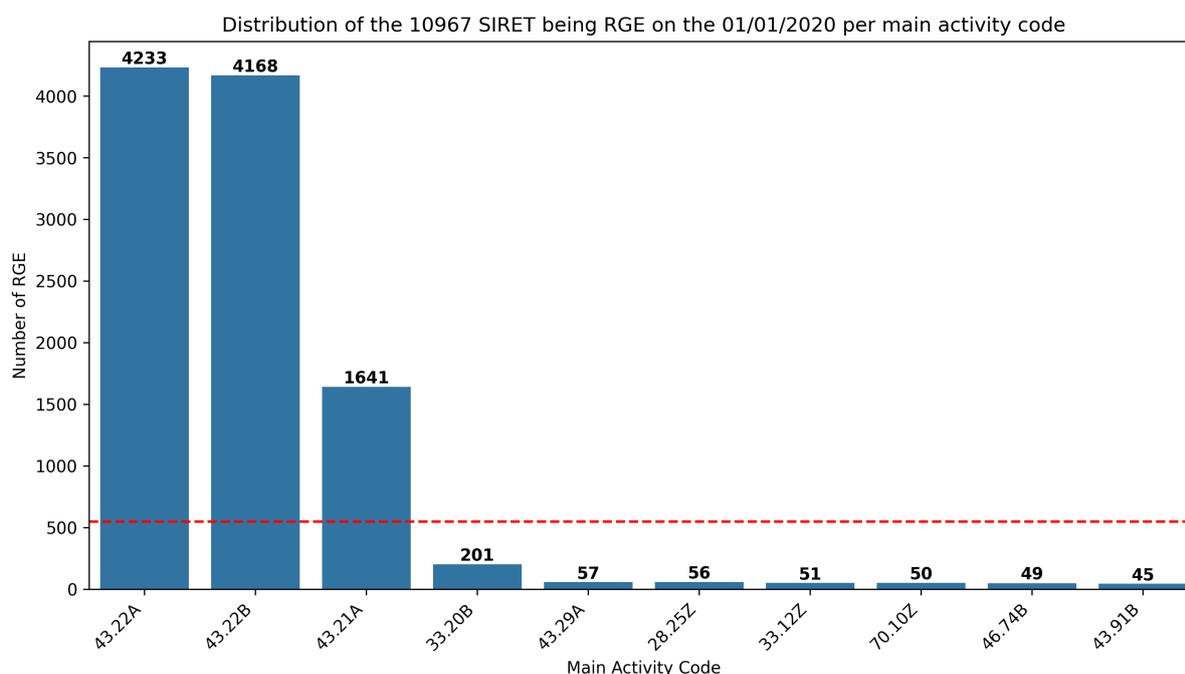


Figure 4: Number of unique RGE establishments per main activity code (01/01/2020)

In 2017 and 2020, the top 3 main economic activity accounts for more than 90% of all certified establishments. The first three main activity codes are 43.22A - water and gas installation work in all premises, 43.22B - installation of thermal and air conditioning equipment, and 43.21A - electrical installation work in all premises. Activities not in the top 3 account for less than 5% of all certified establishments as shown by the dotted red line. Heat-pump installation is likely a secondary activity for these establishments. Thus, we should not account for them because they likely benefit from other policies and subsidies (e.g. insulation).

To build the control and the treated groups, we selected establishments of interest (see Appendix A for details) and we divided them according to whether they were ever RGE-certified or not. We get 109,390 establishments in the control group, and 7,524 in the treated group.

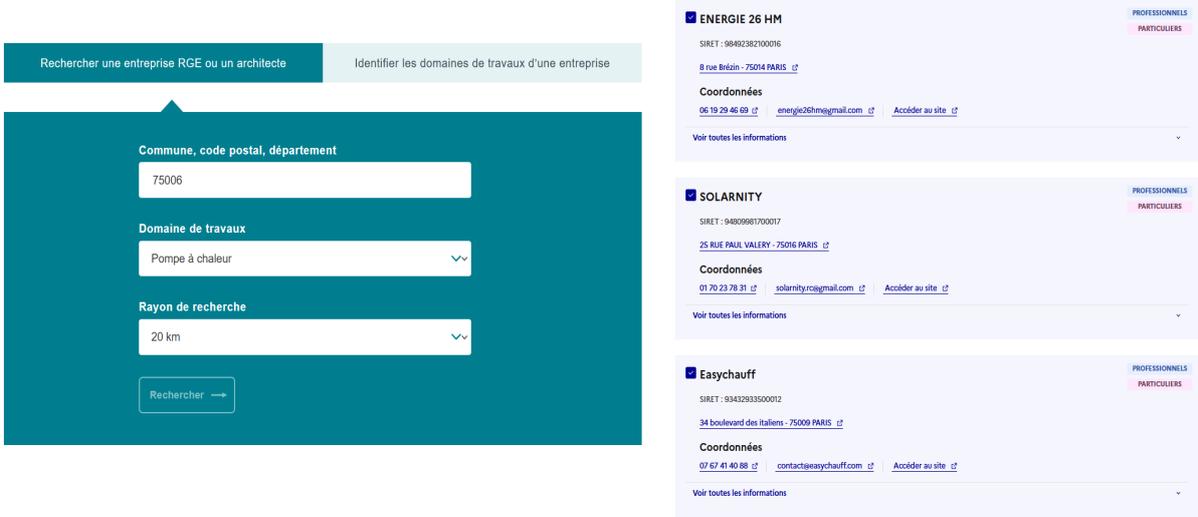
Appendix C : More descriptive statistics

Table 4: Descriptive statistics for each group

	Control group		Treated group	
	Number	%	Number	%
Number of unique establishments	109390		7524	
Population in a 20km radius				
Mean	1.68×10^6	/	0.420×10^6	/
Median	379×10^3	/	157×10^3	/
Mean of the 2021 median income level in a 20km radius (euro)				
Min	17.2×10^3	/	18.8×10^3	/
Mean	25.1×10^3	/	24.0×10^3	/
Median	25.2×10^3	/	23.6×10^3	/
Housing type (TYPL)				
1 : detached house	75 307	68.8	6419	85.3
2 : flat	33 178	30.3	1064	14.1
3-6 : other	905	0.9	41	0.6
Number of room in the housing (NBPI)				
1-3 : 3 rooms or less	34 130	31.2	1591	21.1
4-7 : between 4 and 7	71 213	65.1	5602	74.5
8-20 : 8 rooms or more	4047	3.7	331	4.4
Surface area of the housing (SURF)				
1-4 : 80 m ² or less	40 912	37.4	1915	25.5
5-7 : more than 80 m ²	68 478	62.6	5609	74.5
Main fuel type of the housing (CMBL)				
1 : urban heating network	4923	4.5	81	1.1
2 : mains gas	32 051	29.3	1279	17.0
3 : fuel oil	14 877	13.6	1457	19.4
4 : electricity	36 864	33.7	2383	31.7
5 : bottled gas	2625	2.4	248	3.3
6 : other	18 050	16.6	2076	27.6

Note : The numbers at the beginning of each line are the one in the French 2017 population census (we excluded all lines with CMBL among X, Y, Z).

Appendix D : French Government search engine



(a) Search of a contractor in 2020

(b) Results of a 2025 search

Figure 5: French government search engine (faire.gouv.fr, france-renov.gouv.fr as of 2020)

Appendix E : Exposure

Mathematical formulation. To define the exposure to fuel oil (or gas, or fossil fuel combining oil and gas), we create a rank-weighted average fuel oil (or gas, or fossil fuel) penetration rate across all municipalities within a 20 km radius of each establishment based on the government website ranking system. We define the exposure for each establishment i depending on the municipalities nearby. The mathematical formulation follows :

$$E_i = \frac{\sum_{c \in C_i} FU_c \times W_{i,c}}{\sum_{c \in C_i} TH_c \times W_{i,c}} \quad (4)$$

where

- C_i is the set of communes with 20km of installer i (we considered the municipalities which centroid were below a 20 km distance from the contractor's location)
- FU_c is the number of fuel oil (or gas, or fossil fuel) housing units in commune c
- TH_c is the total number of housing units in commune c (we only considered households with a *CMBL* between 1 and 6 in the 2017 French population census [25])
- $W_{i,c}$ is the rank-based weight for installer i in commune c : $W_{i,c} = \frac{1}{R_{i,c}}$ where $R_{i,c}$ is the rank of installer i among all installers serving commune c .

Mimicking the government search engine. To compute oil exposure, we create 20km buffers around all establishments of interest. All municipalities centroid within the buffer of an establishment j are taken into account for the calculation of the exposure of establishment j . In the figure below, establishment are identified by light blue dots, and municipality centroids are identified by orange dots. Circles represent buffers.



Figure 6: Mimicking the government search engine

Exposure statistics. Below is a table recapitulating main statistics of oil, gas and fossil fuel exposures. These statistics are used to understand the estimated β parameters concerning the econometric models.

Table 5: Statistics about exposure

	Mean	Std Error	Min	Max
E_{fossil}	0.460	0.122	0.033	0.882
E_{oil}	0.126	0.083	0.008	0.524
E_{gas}	0.334	0.165	0.000	0.848

Exposure map. Below is a map of oil exposure on January 2017 in France. It was obtained in QGIS using a Voronoi diagram because exposure is defined at the establishment level. The lighter the zone, the higher the exposure. The blue colors go from 0

to 0.1, the greeny-yellow color goes from 0.1 to 0.32 and the yellow one from 0.32 to 1. Thus, it is consistent to say that oil exposure reflects types of areas (rural or urban).

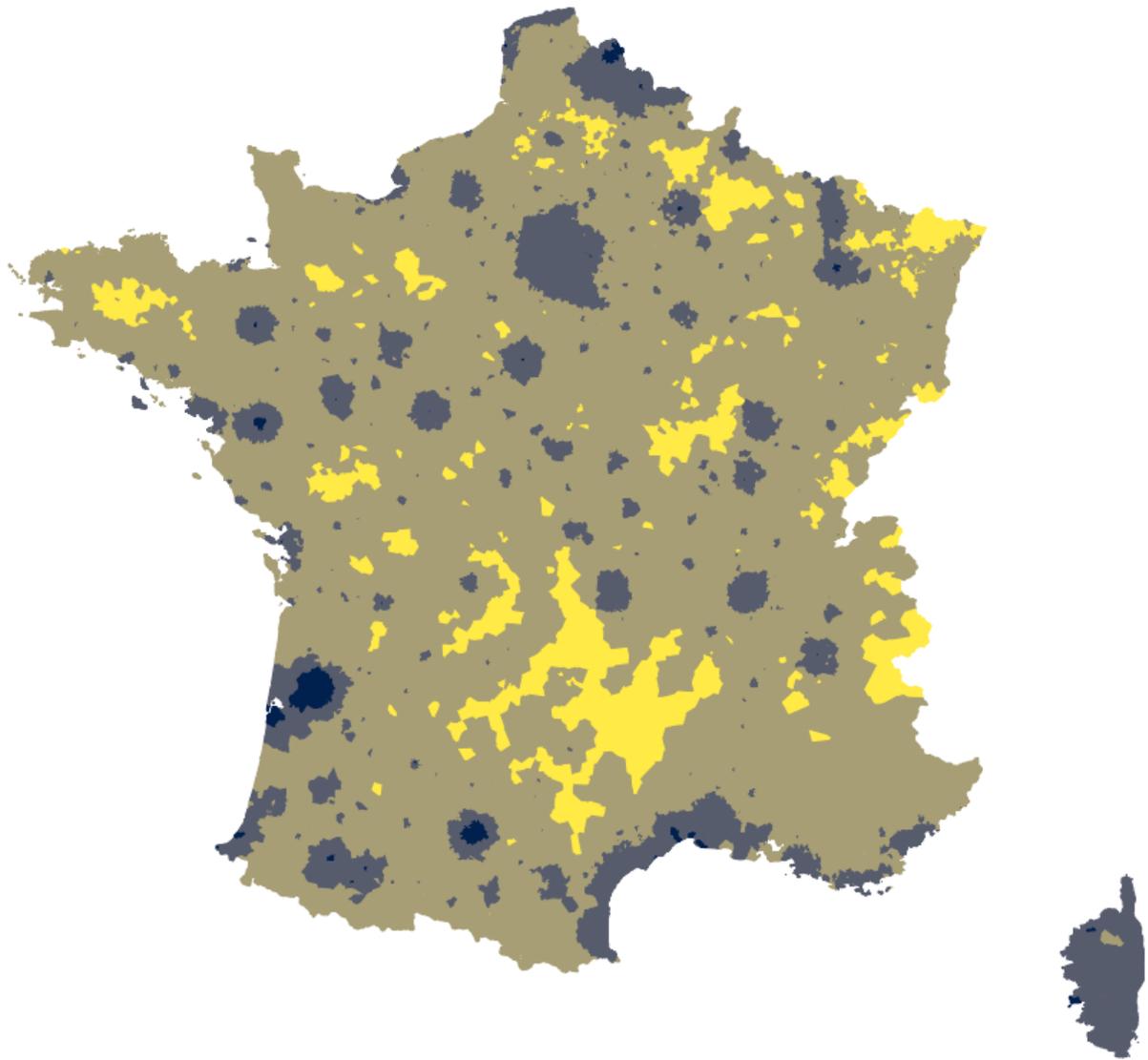


Figure 7: Oil exposure map on January 1, 2017

Appendix F : fossil fuel boiler resale, the rebound effect

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Cuve a fioul 700l roth
300 €

Bricolage
Coësmes 35134



Chaudière à fioul de 2012
300 €

Équipements industriels
Quesoy 22120
aujourd'hui à 13:52



Chaudière fioul et sa cuve
500 €

Livraison possible

Bricolage
Faux-Mazuras 23400

Figure 8: Used boiler for resale on leboncoin.fr on the 13 Nov. 2025