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Do high electricity bills undermine public support for renewables? Evidence from the European Union

Michaël Aklin

Department of Political Science, University of Pittsburgh, 230 S. Bouquet St, Pittsburgh, PA, 15260, USA

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ABSTRACT

The clean energy transition has long been framed in terms of its technological and economic feasibility. An increasingly salient constraint lies in its political feasibility. The transition requires vigorous public support to be completed. Yet increased consumer costs associated with the deployment of renewable electricity could make voters - and, by extension, governments - less supportive of it. As a result, overly aggressive government support for renewables could lead to its own downfall. To examine this threat, I document two stylized facts. First, the expansion of renewable electricity capacity has been followed by an increase in household electricity bills, and this has mostly happened because of energy-specific taxes. An increase of renewable electricity capacity by one within-country standard deviation raises a typical household's bill by €5.7 per MWh (95% CI: [3, 8.3]), most of which comes from an increase in non-VAT taxes (+€3.8/MWh [2.6; 5.1]). Second, these taxes have hurt popular support for aggressive renewable energy policy. An increase of non-VAT taxes by one standard deviation increases the share of people who find renewable energy too ambitious by 0.7 percentage points (95% CI: [0.1; 1.3]). Climbing costs could therefore undermine further political support toward renewable electricity deployment and threaten its contribution to greenhouse gas reductions.

1. Introduction

International climate governance increasingly relies on the successful deployment of clean energy to curb greenhouse gas emissions (Turner, 1999; IPCC, 2011; Keohane and Victor, 2011; Victor, 2011). Modern renewables such as solar PV and wind power already contribute a large and increasing share of electricity, especially in the European Union (EU) (Fig. S1). The success of renewable energy can be credited to effective public support by sympathetic governments (Aklin and Urpelainen, 2018). Policies such as feed-in tariffs and renewable portfolio standards increased the competitiveness of renewables and weakened the hitherto dominant position exerted by fossil fuels and nuclear power (Unruh, 2002; Sawin, 2006).

Whether industrialized societies can complete their clean energy transition in a timely manner remains an open question. It has certainly generated fierce debates. Decarbonizing electricity (for instance by ramping up modern renewables) appears increasingly feasible from a technical standpoint (Lund, 2007; Lund and Mathiesen, 2009; Mathiesen et al., 2011; Zappa, Junginger, and van den Broek, 2019) but the cost of doing so remains contentious (Jacobson et al., 2015; Clack et al., 2017). Many studies cast the problem in terms of technology availability and economic efficiency. Doing so, however, may miss another binding constraint. If the clean energy transition requires vigorous public support to be completed, but if such support is too costly for voters, then the effective constraint on the clean energy transition might be its *political* feasibility. In other words, even if switching to a 100%-carbon-free energy system were technically feasible and economically affordable in the aggregate, it may not be politically sustainable if consumer costs rise too much, too fast.

As long as renewables require state support to maintain investments and build capacity, they remain dependent on governments' – and therefore voters' – goodwill. Previous studies have established the importance of industrial lobbying on renewable energy policy (e.g., Sovacool, 2009b; Marques et al., 2011; Stokes, 2020). In this paper, the focus lies on voters, given their pivotal role in democratic regimes. Pro-renewable regulations will only remain in place if they can muster enough public support from essential stakeholders (Roe et al., 2001; Stokes, 2013; Bayer and Urpelainen, 2016). There is increasing evidence that renewable energy technologies are sometimes met with disapproval by voters. This is particularly the case when development plans clash with the preferences of local communities (Walker and Devine-Wright, 2008; Musall and Kuik, 2011). One study in Canada shows that the

E-mail address: aklin@pitt.edu.

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presence of wind turbines decreases the vote share of incumbents by 4–10% (Stokes, 2015). If pivotal constituencies find these policies too costly, then governments will eventually dismantle them. This would be a considerable blow to the renewable energy sector which still relies on sympathetic governments (Aklin, 2018).

To assess this problem, this article addresses two interlinked questions: (a) are household electricity bills positively correlated with the deployment of renewables? and (b) how do higher bills affect public opinion on pro-renewable policies?[1] If the growth of renewables increases consumer bills, then public hostility against renewable energy may stiffen. This could be true even if renewables and bills do not share a causal link and are only (spuriously) positively correlated: as long as consumers blame renewables for higher costs, then the same pattern may emerge.

I respond to these questions by drawing on a panel dataset of 28 EU countries between 2006 and 2015. The focus lies on households because, as voters, they represent an important political force that is directly affected by energy pricing, as recent cases in France,[2] Germany,[3] and the UK show.[4]

The empirical analysis provides evidence that the deployment of renewables coincides with higher household electric bills, and that voters have become more hostile to renewable energy policy because of it. Using two-way fixed effects models, I document the following results. First, I show that the deployment of renewables is positively correlated with higher electric bills. In particular, taxes on electric bills are higher in countries with more renewables. This helps us understand why citizens may believe that their bills is affected by renewables.[5] Second, I show that higher taxes lead to lower public support for pro-renewable energy policy. Together, these findings have important policy implications. The pace at which renewables can be deployed might be constrained by public hostility stemming from higher consumer costs. In the concluding section of the paper, I discuss policy solutions that can soften such constraints, such as debt-funded deployment of renewable capacity.[6]

This paper contributes to two streams of scholarship. First, it adds to a growing literature that warns about the political limits to radical changes of energy systems. Researchers have emphasized the role played by politicians in energy and climate policy (Breetz et al., 2018; Genovese and Tvinnereim, 2019; Mildenberger, 2020). Several studies have highlighted the importance of interest groups, such as utilities, in slowing down or speeding up the clean energy transition (Aklin and Urpelainen, 2018; Stokes, 2020). Another line of research has noted that public opinion may also impose constraints on policymakers' ability to deploy clean energy (Stokes, 2015). Here, I show the negative impact of consumer costs on voters' willingness to support pro-renewable policies.

Second, this paper contributes to the literature on the energy justice (Sovacool and Dworkin, 2015; Jenkins et al., 2016) and the just transition (Newell and Mulvaney, 2013; McCauley and Heffron, 2018; Pai et al., 2020). As the poorest are the most affected by energy poverty and high energy costs (Bednar and Reames, 2020; Bouzarovski et al., 2012), understanding how to make the transition fair matters not just for ethical but also for political reasons. This paper offers empirical evidence that insufficient attention to distributive concerns leads to policy failures.

What follows builds on these two research programs and focuses on the chain linking the deployment of renewable energy, consumer costs, and public attitudes toward ambitious clean energy policy. The speed of deployment of clean energy depends not only on innovations and on the reduction of overall costs, but on the tolerance of voters to higher consumer costs. Thus, while speedy deployment of clean energy is necessary from a climatic perspective, it may not constitute a feasible path from a political standpoint. I return to the policy implications of this study in the concluding section.

2. Research design

This article investigates two linked questions. First: are renewables associated to an increase in household electricity spending? Second: does an increase in electricity bills induced by renewables cause a decline in public support for renewable energy policy? I briefly explain the rationale behind these two claims before discussing the data and the empirical analysis conducted below.

2.1. Hypotheses

The main policy tools used to promote renewable energy usage for grid electricity are feed-in tariffs (FITs) and renewable portfolio standards (RPS). FITs force utilities to buy renewable energy at a set price. RPS require utilities to generate a certain share of electricity from renewable sources. Both cases involve costs to utilities, including the construction of renewable capacity, its connection to the grid, or its maintenance.

Some of these costs are likely to be passed on to consumers. An example is Germany's *Erneuerbare Energien Gesetz* (EEG, or Renewable Energies Law), the law that regulates the country's FIT (Traber et al., 2011; Loreck et al., 2012; Cludius et al., 2014a,b). The EEG was designed to minimize the cost of renewables to the state's budget. Instead of leaving public finances on the hook, a surcharge that would cover the extra costs generated by the deployment of renewables was added to electric bills. When the spot price of electricity remains below the guaranteed price, the difference is billed to consumers. Then, even though renewables depress spot prices (by adding capacity), they can generate extra costs via the FIT's set price (De Miera et al., 2008; Forrest and MacGill, 2013). In practice, large consumers (such as heavy industries) tend to benefit from lower wholesale prices while small consumers (such as households) tend to pay more (IEA, 2013, 131). This has been the experience of countries such as Australia, Germany, or Spain – some of the global leaders in renewable energy generation (Würzburg et al., 2013; Cludius et al., 2014b).

Note that adding renewable capacity does not directly increase bills in a causal manner. In theory, governments could hide these costs by subsidizing power providers. Some countries, such as Portugal and Spain, rely on debt (or tariff deficit) to push the cost of renewables on future tax payers (Linden et al., 2014). This mechanism weakens the relationship between the deployment of renewables and the costs faced by consumers. I return to this point in below. Instead, the question that is addressed here is whether governments or utilities *in practice* fund the expansion of renewables via specific taxes that were added to consumer bills. If that were the case, then we could suspect that consumers link renewables to higher costs.

The first set of hypotheses, then, consist in the following claims: the

[1] In this paper, renewables are always meant to include modern sources only (PV, wind, etc.). As a mature technology, hydropower is not included, except if otherwise stated.

[2] "Sortir du nucléaire ou y rester: un coût astronomique," *Le Monde*, April 3, 2017, http://www.lemonde.fr/energies/article/2017/04/03/sortir-du-nucleaire-ou-y-rester-un-cout-astronomique_5104819_1653054.html.

[3] "Energiewende kostet die Bürger 520.000.000.000 Euro – erstmal," *Die Welt*, October 10, 2016, https://www.welt.de/wirtschaft/article158668152/Energiewende-kostet-die-Buerger-520-000-000-000-Euro-erstmal.html.

[4] "Theresa May to promise price cap on energy bills in Tory manifesto," *The Guardian*, May 9, 2017, https://www.theguardian.com/money/2017/may/08/theresa-may-to-promise-price-cap-on-energy-bills-in-tory-manifesto.

[5] Note that the EU's official policy was to raise the share of renewables *to* 20% and not increase it *by* 20%. The wording from Eurobarometer does thus not exactly match EU policy. This discrepancy seems common across the different translations of the Eurobarometer questionnaire. I thank a reviewer for bringing this to my attention.

[6] "Theresa May to promise price cap on energy bills in Tory manifesto," *The Guardian*, May 9, 2017, https://www.theguardian.com/money/2017/may/08/theresa-may-to-promise-price-cap-on-energy-bills-in-tory-manifesto.

deployment of renewable electricity capacity is expected to increase consumer bills (H1), especially via an increase in taxes levied to support clean energy (H2).

The next step links the cost of renewable electricity to public support for government action to expand its deployment. The more people pay for their electric bill (especially on extra taxes), the less supportive of aggressive policies they should be. Assuming that households have a fixed budget, higher spending on electricity must be compensated by a commensurate decline in spending on other goods. As a result, additional renewables must generate tangible benefits. The problem is that much of the benefits from renewables stem from positive externalities, and therefore are not entirely captured by customers (Brown, 2001). Thus, as electric bills climb, people will prefer the costs to be shared across a wider base. This idea takes its roots in public good theory, where individuals benefit from it but their contribution is irrelevant (Ostrom, 1990).

My last hypothesis (H3), then, states that individual support for government action on renewables declines in response to the size of the electric bill that people face. In such cases, people prefer slowing down or even scaling back public programs that promote renewable energy.

Note here that H3 does not require H1 and H2 to be true. It suffices for H3 to be consistent that people *believe* that their costs are affected by renewable energy deployment. People are notoriously poorly informed about political and economic issues (Calcagno and Monticone, 2015; Klašnja, 2017). Under bounded rationality, H3 may hold as long as individuals find it plausible that their bills increase because of renewable energy (Sovacool, 2009a). Evidence from survey experiments suggest that people are indeed sensitive to the cost of renewable energy on their bills (Stokes and Warshaw, 2017).

Notice also that there could be two mechanisms linking a change in electric bills to preferences over public policy. The first one is about blame attribution. Individuals who believe that there is a connection between renewables and their bills may blame the former for the latter. In the absence of complete information, individuals often use mental causal models to form their views (Iyengar, 1989). The second mechanism relies on a budget effect. Higher spending on renewable reduces disposable income, which in turn makes people less willing for states to engage in public spending (especially over what may be seen a luxury goods). While both mechanisms depend on a cost effect (i.e., higher bills), their implications differ. In the latter, any kind of income shock should reduce willingness to spend on renewables. In the former, only increased costs that people attribute to renewables should matter. In the empirical section, I evaluate evidence for either of these two mechanisms, finding stronger evidence for the blame-attribution one.

Fig. 1 summarizes the theoretical argument. Taken together, these two hypotheses have serious implications. If renewables increase consumer costs, and if consumer costs depress public support for clean energy policy, then a hasty deployment of renewable energy could undermine long-term support for its deployment. By 'hasty,' I mean a deployment scenario in which costs climb rapidly, leaving little room for learning and other cost-reducing effects to kick in. This would imply that the rapid deployment of renewable energy is constrained not so much by technical constraints but by the fact that there exists no equilibrium in which voters would agree to it. This puts an upper bound on the speed at which clean energy can be used to mitigate a problem such as climate change.

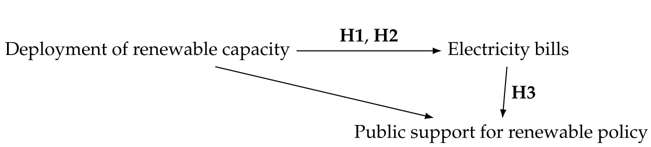

Fig. 1. Stylized causal path.

2.2. Data and models

I evaluate the plausibility of these three hypotheses against a panel dataset of EU countries. The sample includes all 28 EU countries over the 2006–2015 period (Malta, in some cases, is dropped because of data limitations). The advantage of focusing on Europe is that they offer a relatively homogeneous set of countries and harmonized data sources. The argument presented in this paper should, however, travel to other regions.

I use two sources to measure the burden of renewables on consumers (all variables are summarized in Table 1). First, EUROSTAT provides average residential electricity prices. It includes the overall average bill and the taxes paid by households (€/MWh). I focus on the costs faced by a typical household, defined here as one that consumes between 2,500 and 5,000 kWh per year. I test H1 by examining whether renewable electricity capacity affects the bill faced by households.

EUROSTAT provides more fine-grained information by computing both the pre-tax bill and the total taxes added to it. Taxes are further split between value-added tax (VAT) and non-VAT taxes. VATs are applied across most consumer goods and services and are generally not specific to electricity. Thus, the deployment of renewable electricity should have no or little effect on VAT. Non-VAT taxes, on the other hand, comprise all other surcharges, including renewable energy ones. These are taxes that should be affected by the renewable electricity capacity. These are also the taxes that should depress public support for aggressive renewable energy policy. I use this outcome to test H2.

It is important to note that some of the non-VAT taxes may include taxes that are not directly related to renewable energy. Finer grained data are unfortunately not readily available. However, I verified whether taxes were correlated with feed-in tariffs for wind and solar; this helps assess whether the non-VAT variable reacts to higher guaranteed prices. Ideally, non-VAT would be positively correlated with feed-in tariffs, whereas VAT would not. And indeed, this is what I find (Table S6).

Second, European Commission (2016) provides data that specifically measure financial support for renewable energy: costs related to technology, grid connection, and other forms of support. Such support is also measured in € per MWh. I use these data as a complement to non-VAT taxes to provide a second test of H2.

To test H1 and H2, the key independent variable consists in the amount of renewable electricity capacity deployed in a given country (in GW). The data are collected by the IEA. The variable sums the capacity of wind power, solar PV and thermal, and geothermal. Hydropower is

Table 1
Descriptive statistics of the variables used in this analysis. Sample limited to EU28 countries since 2006.

	Mean	Median	S.D.	Min.	Max	Obs.
Electricity price (EUR/MWh)	165.89	161.00	50.52	72	309	279
All electricity taxes (EUR/MWh)	44.38	33.60	36.90	3	212	277
Electricity VAT (EUR/MWh)	24.67	24.15	11.45	3	62	279
Non-VAT electricity taxes (EUR/MWh)	19.66	10.65	28.11	0	150	277
Support renewable energy (EUR/MWh)	10.41	6.56	13.01	0	67	130
Respondents who find renew. policy too ambitious (%)	18.99	19.00	4.61	10	31	193
Renewable capacity (GW)	5.94	1.49	13.96	0	104	344
GDP per capita (log)	10.21	10.27	0.64	9	12	364
GDP (log)	26.08	26.19	1.57	23	29	364
Industry (log of value added)	24.70	24.84	1.52	21	28	352
Share of left-wing in government (%)	31.52	22.58	32.25	0	100	252

excluded because it is a mature technology.

The estimates reported in Table 2 are based on models of the following kind:

$$\text{Outcome}_{c,t} = f(\text{Renewable Capacity (GW)}_{c,t-1}) + \mathbf{X}_{c,t-1}\lambda + \kappa_c + \tau_t + \epsilon_{c,t},$$

where subscripts c and t indicate countries and years, respectively.

Since capacity can change over the course of a year, this variable (and control variables, when applicable) is lagged by one year. I estimate these models in two ways: first with least squares, in which I assume that the effect of renewable energy capacity ($f(\cdot)$) is linear; second with a semi-parametric model, where I relax this assumption (Robinson, 1988). I expect the latter to offer similar qualitative results to the linear model. For inferences, standard errors are clustered by country, which allows correlation of errors within countries.

All statistical models include country (κ_c) and year (τ_t) fixed effects. Parameters are therefore identified based on variation within countries. This ensures that country-specific features, such as their wind or solar potential or their natural resource stocks, are adjusted for (at least over the period covered by the data). Country fixed effects also adjust for very slowly moving factors, such as the overall political climate of a country. Year fixed effects account for European-wide shocks, such as the rapid change in the cost of renewable energy parts or variation in the price of fossil fuels. In addition, I adjust for GDP per capita and population (both in log form) ($\mathbf{X}_{c,t-1}$). Wealthier countries may find it easier to afford renewable energy in a way that spares consumers. Larger countries may be able to benefit from economies of scale. Including population also normalizes the effect of renewable capacity, while allowing us to distinguish the effect of capacity and population growth.

Below, I report the estimates of these parsimonious models. More complicated models increase the risks of including post-treatment control variables which would introduce bias in the estimates (Montgomery et al., 2018). Nevertheless, the appendix contains models that adjust for additional confounding factors, including the value added by the industrial sector, the share of employment in the industrial sector (on the economic side) and the percentage of government cabinet seats held by left-wing parties (on the political side) (Table S1), with no substantial impact on the findings.

To test H3, I examine public opinion data from Eurobarometer. A survey conducted across Europe, Eurobarometer has on occasion asked respondents whether they found renewable energy policy too ambitious or not. The dependent variable is the percentage (0–100%) of respondents saying that it is "too ambitious" to increase the share of renewable energy in the EU by 20% by 2020.[5] The advantage of this outcome is that it asks respondents about a common target for the EU and therefore is more easily comparable across countries. Statistical comparison across countries would be more difficult if, for instance, the question had been about country-specific targets.

The estimates reported in Table 3 are based on the following model:

$$\text{Renewable policy is too ambitious (\% of resp.)}_{c,t} = f(\text{Tax}_{c,t}) + \mathbf{X}_{c,t-1}\lambda + \kappa_c + \tau_t + \epsilon_{c,t}.$$

As above, I estimate both a linear and a semi-parametric version of the model.

The last step is to verify the plausibility of the entire model depicted in Fig. 1. I rely on causal mediation models (Baron and Kenny, 1986). Mediation analysis requires strong assumptions (sequential ignorability) that are typically not verifiable (Imai et al., 2010; Imai et al., 2011). The results must therefore be read with considerable caution. For completeness, I report the estimates of the average causal mediation effect (i.e., the indirect effect operating from renewables to public opinion via energy taxes) and how it compares to the total effect. For this, I draw on the implementation established by Hicks and Tingley (2011).

Table 3
Linear model estimated by OLS. Dependent variable: percentage (0–100%) of respondents saying that it is "too ambitious" to increase the share of renewable energy in the EU by 20% by 2020. Standard errors are reported in parentheses and are clustered by country. Symbols: *: $p < 0.1$; **: $p < 0.05$; ***$p < 0.01$.

	(1)	(2)	(3)	(4)
All electricity taxes (EUR/MWh)	0.06*			
	(0.03)			
Electricity VAT (EUR/MWh)		0.05		
		(0.06)		
Non-VAT electricity taxes (EUR/MWh)			0.09**	
			(0.04)	
Support renewable energy (EUR/MWh)				0.12*
				(0.07)
GDP per capita (log)	10.56*	9.03	9.94**	12.89
	(5.25)	(5.82)	(4.83)	(8.07)
Population (log)	17.51*	14.34	15.41	11.87
	(9.61)	(9.82)	(9.52)	(20.99)
Country FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Observations	193	193	193	102
# Clusters	28	28	28	26
R^2	0.79	0.78	0.79	0.82
Mean of DV	18.99			
SD of DV	2.77			

Table 2
Linear model estimated by OLS. Dependent variables listed at the top of each column. *Incl. All Taxes* is the average electricity bill (measured in €/MWh) including all taxes to a typical household consuming between 2,500 and 5,000 kWh. *Net of Taxes* is the average electricity bill net of all taxes (VAT and non-VAT). *All Taxes* is the total amount of all taxes (in €/MWh) paid by the same household. *VAT* is the value-added tax paid by households on the same bill. *Non-VAT* are all other taxes. *Renew. Support* is the amount of subsidies for renewable energy and combined heat and power (in €/MWh). Standard errors are reported in parentheses and are clustered by country. Symbols: *: $p < 0.1$; **: $p < 0.05$; ***$p < 0.01$.

	Electricity Prices (EUR/MWh)		Taxes and Support (EUR/MWh)			
	(1)	(2)	(3)	(4)	(5)	(6)
	Incl. All Taxes (**H1**)	Net of Taxes	All Taxes	VAT	Non-VAT (**H2**)	Renew. Support (**H2**)
Renewable capacity (GW)	1.16***	0.34	0.96***	0.11	0.81***	1.01***
	(0.28)	(0.34)	(0.12)	(0.07)	(0.13)	(0.07)
GDP per capita (log)	−73.02**	−25.40	−51.86***	−25.19**	−25.68	−27.81
	(30.37)	(20.92)	(17.94)	(10.45)	(17.05)	(18.85)
Population (log)	−116.93	−10.32	−104.48*	−58.23**	−46.75	−51.14
	(80.35)	(65.53)	(51.94)	(25.11)	(35.04)	(41.67)
Country FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	262	260	260	262	260	122
# Clusters	27	27	27	27	27	25
R^2	0.93	0.88	0.95	0.89	0.95	0.90
Mean of DV	167.47	120.72	46.43	25.48	20.90	11.07
SD of DV	21.54	12.99	13.44	5.25	9.61	7.78

3. Electricity pricing patterns

Despite increasing convergence of its regional electricity markets (European Commission, 2016), renewable energy policy in Europe remains fragmented and under the control of national governments (Rusche, 2015). As of 2014, out of 28 EU countries, 24 had implemented a FIT and 4 an RPS. These policies have enabled the EU to have one of the highest penetration rate of renewables. Often cited as an example, Denmark produced 60.7% of its electricity from non-hydro renewable sources in 2015. Others, like France, lag behind (6.1% in 2015). Studies from the US and elsewhere suggest that energy policies were instrumental in promoting the rapid growth of renewables (Smith and Urpelainen, 2014).

How costly were these policies to the average household? Drawing on data from the EU, I examine whether increasing renewables capacity had an effect on household prices. First, I explain variation in the bill (in €/MWh) faced by a typical household with the amount of renewable energy capacity (in GW) deployed in a country. In 2016, an average household spent between €59.1 (Kosovo) and €308 (Denmark) per MWh, with the continent-wide (unweighted) average being €156/MWh.

I begin by examining the electricity bill including all taxes (Table 2, model 1). Each additional GW of capacity from renewables is associated with an increase in household price by about €1.2/MWh (95% CI: [0.6, 1.8]) on average. A more realistic increase of capacity by one within-country standard deviation (~4.9 GW) is linked to an increase in cost by about €5.7/MWh (95% CI: [3, 8.3]), or about one-quarter of its own standard deviation. To push this analysis further, I replicate the same analysis by looking at electricity price net of taxes (model 2). The effect of renewables disappears almost entirely; the point estimate is about the same size as its standard error, pointing at a small and imprecise effect.

This suggests that the real culprits behind price hikes are taxes. Models (3) to (5) look at three different sets of taxes: all electricity taxes (model 3), value-added tax (VAT, model 4), and non-VAT taxes (model 5). VAT taxes are common in Europe and are generally set across industries. As such, it is not an energy-specific tax. Non-VAT taxes, on the other hand, include energy-specific taxes. Finally, in addition to taxes, I model the broader level of financial support for renewables by the government, which includes costs such as connecting renewable generating units to the grid (model 6). All these variables are measured in €/MWh.

The effect of added capacity is almost entirely driven by the increase in non-VAT taxes (model 5). Increasing capacity by one standard deviation increases non-VAT taxes by €3.8/MWh (about 40% of its standard deviation) (95% CI: [2.6; 5.1]). Model 6 shows very similar point estimates. In fact, the effect is even steeper. An increase of support by 1 GW increases support by €1/MWh; an increase of one standard deviation leads to an increase of support by €4.7/MWh (95% CI: [3.9; 5.5]). These results are not dependent on an assumption about a linear effect of renewable energy capacity. If we use a semiparametric approach, and let capacity (here normalized by million inhabitants) have a nonlinear effect, we find very similar results (Fig. 2).

In the appendix, I examine the effect of engaging in tariff deficit (Table S3). I find that countries that engage in tariff debt have lower average bills by about €9/MWh, although the effect is not statistically significant. I also find that they provide higher subsidies to renewables, as one would expect.

From the perspective of the consumer, the implications are that (a) there is a price hike associated to renewables, and (b) this price increase is driven by taxes, and as such is caused by government intervention. Overall, the build up of renewable electricity capacity has generated a significant and substantial increase of the cost of energy for households.

4. Effect of electricity support on views over renewable energy policy

Next, I explore the effect of price increases on public support toward renewable energy regulation. Since 2010, Eurobarometer asks respondents of EU countries what they think about a policy that would "increase the share of renewable energy in the EU by 20% by 2020." For each country, I take the percentage of people who claim that such a policy is "too ambitious." This is the share of people who would be most likely to veto further expansion of renewable energy policy. On average, this share increased from 16% in 2010 to 21% in 2016. The yearly increase in the share of skeptical individuals has thus been about 0.8%.

The results are reported in Table 3. Aggregate support for ambitious renewable energy policy declines when taxes increase (models 1–3). More precisely, support decreases when non-VAT taxes go up. Support is only weakly affected by VAT changes. An increase of non-VAT taxes by one within-country standard deviation (€7.9) increases the share of people who think that a policy of 20% of renewables by 2020 is too ambitious by 0.7 percentage points (95% CI: [0.1; 1.3]). Taxes can therefore explain about one-quarter of the variation in public support. These findings are confirmed if we let the effect of non-VAT taxes be nonlinear (Fig. 3). A shift from the lowest level of support to the highest leads to an increase of disapproval by about 10 percentage points, or 50% (from about 20% to 30%).

Note that these effects *augment* existing trends toward more

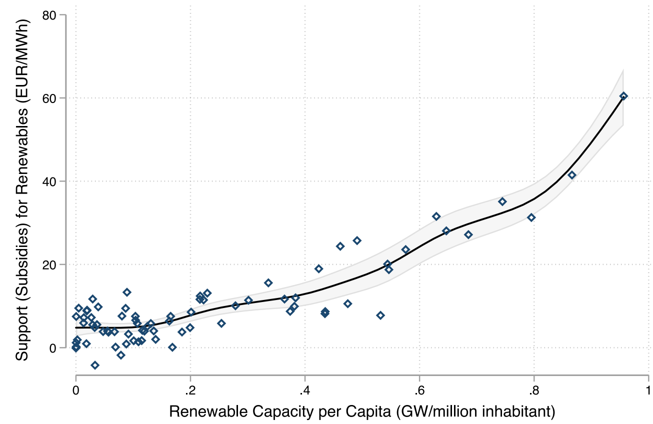

Fig. 2. Semiparametric regression. Dependent variable: subsidies for renewable energy sources and combined heat and power, measured in €/MWh. A linear regression with country and year fixed effects is fitted. Residuals are then fitted as a function of renewable energy capacity (in GW/million inhabitants). The band denotes a 95% confidence interval.

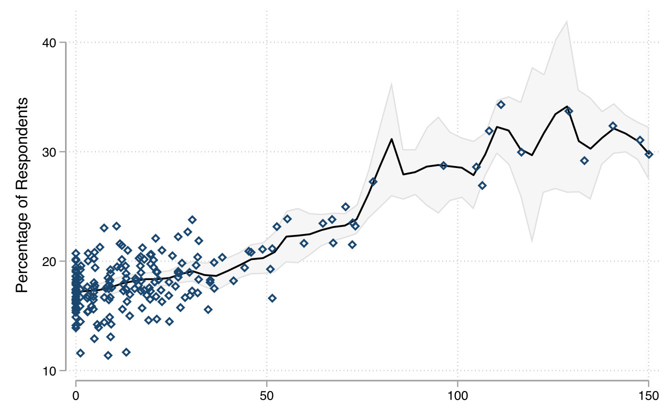

Fig. 3. Semiparametric regression. Dependent variable: percentage (0–100%) of respondents saying that it is "too ambitious" to increase the share of renewable energy in the EU by 20% by 2020. A linear regression with country and year fixed effects is fitted. Residuals are then fitted as a function of non-VAT taxes on electricity (in €/MWh). The band denotes a 95% confidence interval.

skepticism. The estimates of the year fixed effects (not reported) show an almost monotonic increase in skepticism over climate policy on average for all countries. Increasing prices therefore reinforce an already adverse trend.

To confirm the role of renewable energy policy, I compute the same estimates but use data on government support for renewable energy sources and combined heat and power. The results are similar: an increase of that variable by one standard error increases hostility by 0.8 percentage points, but with a wider confidence interval (95% CI: [-0.1, 1.8]). The effect becomes a bit larger when additional control variables are added to the regression model, but the estimate becomes less precise, partly because of decreasing sample size (Table S4 model 4).

Next, I report the estimates from mediation analysis (Imai et al., 2010; Imai et al., 2011), as implemented by Hicks and Tingley (2011). The results are reported in Table 4. Prior to estimation, the independent variables were standardized to have a mean of zero and standard deviation of 1. Thus, an increase of renewable capacity by one standard deviation increases dissatisfaction by about 2 percentage points (95% CI: [0.07, 3.78]). The effect appears to operate via taxes. More than half of the total effect of renewable capacity deployment on hostility to aggressive policy appears to operate through higher taxes. As noted earlier, however, these results must be interpreted with caution, given the strong assumptions needed for mediation analysis to yield unbiased estimates.

Lastly, I evaluate the two competing mechanisms I discussed earlier. Do people become less supportive because they blame renewables? Or do they become less supportive because of an income shock? I evaluate each in two ways. First, at the state level, I re-estimate the main models using several proxies for financial issues (unemployment, GDP growth, and inflation); the main results remain qualitatively the same (Table S4). Second, in Table S5 I use individual-level data from Eurobarometer. I interact a person's self-reported level of financial anxiety with average bills (the latter does not vary within states and is therefore absorbed by the country fixed effects). If the budget mechanism were true, we would expect bills to have a larger effect among respondents in financial dire straights. This is not what I find, which suggests that the blame-attribution mechanism is more likely to be accurate.

5. Conclusion and policy implications

The global climate regime is built on the notion that clean energy must be rapidly deployed to curb greenhouse emissions (Victor, 2011). Considerable effort has been devoted to improve the technical feasibility of a transition from fossil fuels to renewable electricity. While many technical obstacles have been removed, there remains the essential question of burden sharing: who should pay for the transition? And who will pay for it in the future? Government support for renewables has not slowed down; in fact, it has generally increased in the EU over the last few years (Fig. 4).

In many countries, electricity consumers have been asked to bear part of the costs. This, as this paper shows, may have serious implications. Placing too much of the burden on households may reduce their willingness to support further action. This matters, of course, because these households are not only consumers but also voters. In this latter capacity, they may prefer to elect politicians who promise to reduce the cost that they face. And indeed, anecdotal evidence from countries such as the United Kingdom, where then-Prime Minster Theresa May promised to cap electric bills, show that politicians take these concerns seriously.6 Electricity pricing is undoubtedly a politically sensitive topic (Linden et al., 2014, 22). While asking consumer to pay the bill for a clean electricity system might be just, it might not be effective.

Instead, alternative strategies such as relying on public debt could be justified on political grounds as an expedient way to diffuse hostility toward renewable energy. Doing so would spread the burden of decarbonization across generations: future taxes would contribute to present-day decarbonization. Doing so can also be ethical, insofar as it relieves

Table 4
Mediation analysis. The explanatory variables were standardized to have mean zero and standard deviation 1. Estimates can be interpreted as the effect of an increase of renewable electricity capacity by one standard deviation.

Quantity	Mean effect	95% confidence interval
Average causal mediation effect	1.14	[0.18, 2.24]
Direct effect	0.86	[-1.2, 2.95]
Total effect	2	[0.07, 3.78]
Share of effect mediated	0.56	[0.26, 2.6]

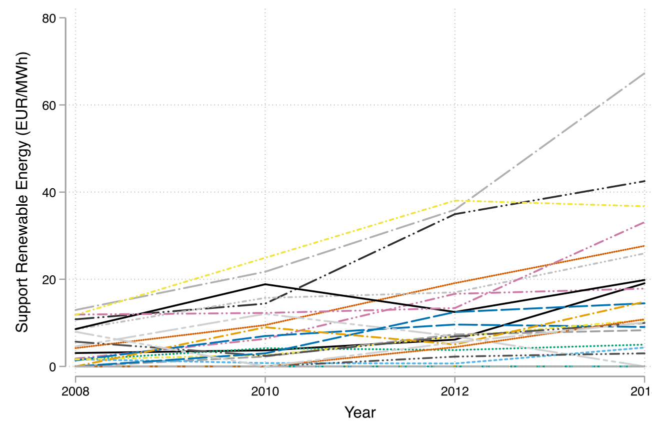

Fig. 4. Government support for the deployment of renewable energy sources and combined heat and power (measured in €/MWH). Each line represents a separate EU country. Data available for 2008, 2010, 2012, 2014, and 2015. Linear imputation between each observation.

the energy poor from increasing electricity costs. Several studies have documented the burden of energy bills even amongst the richest countries (Bouzarovski et al., 2012; Bednar and Reames, 2020).

The broader implication of this study is that the speed of the clean energy transition depends on political constraints. Technological problems must be dealt with, but doing so will not suffice if voters lose appetite for clean energy policy. This paper suggests that a transition that starts too fast (and where presumably prices increase quickly) may undermine future support for aggressive decarbonization. Speeding the transition may therefore not be politically feasible.

This does not necessarily spell out certain doom for the clean energy transition. Instead, these results suggest that there is a need to alleviate painful costs for households. Governments who may wish to reduce these risks could (a) reduce energy taxes, and, where feasible (b) cross-subsidize renewables to reduce the impact on consumers. It ought to do with an eye on the most vulnerable households, which in some countries have been particularly taxed (IEA, 2013, 131). While this may have detrimental climatic effect in the short run by stimulating demand, it would reduce the likelihood of political opposition to the completion of the energy transition. Failing to do so could considerably weaken the global climate architecture around the Paris Agreement.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.enpol.2021.112400.

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