Dynamic electricity tariffs are not as risky as they seem: Peak-to-Bill Anxiety

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Overview

Future carbon-free energy systems will predominantly depend on electrified heating and mobility, powered by intermittent renewable electricity. However, since wind and solar energy are not always available when needed, demand must become more flexible to avoid and reduce substantial investments in generation and transmission capacities. A potential source of this flexibility could be households. Nevertheless, under the prevailing fixed-price retail tariffs, households have no incentive to adjust their demand in response to scarcity signals from electricity generation or the grid - such as by changing their behavior in the short term or investing in storage technologies in the mid-term. This has prompted global initiatives to adjust tariff structures so that corresponding signals are effectively transmitted to households. For instance, both the European Union's Electricity Directive 2019/944 and the United States' Energy Policy Act of 2005 (EPAct 2005) promote offering, alongside fixed-price tariffs, an optional dynamic tariff based on spot market prices. Gradually, these tariffs should be supplemented with dynamic components that improve grid utilization and help prevent overloads (EU Directive 2023/1791). Dynamic and smart tariffs have already become widely established in the UK, with 22% of households participating in smart and dynamic tariff solutions[1], compared to only 7%[2] or less[3] in Germany and Luxembourg.

Given that the success of the energy transition is closely linked to the flexibility of household demand – and, thus, the success of dynamic tariffs - it is time to evaluate the consumers' perspective and examine the barriers to switching to real-time pricing. The current literature merely identifies the complexity of dynamic tariffs (Layer et al., 2017) and overlooked transaction costs (Bejan et al., 2021) as barriers to tariff adoption. To gain a more nuanced understanding of the mechanisms underlying these barriers, we conducted an analysis of the practical experiences and expectations of key stakeholders concerning dynamic tariffs through structured discussions. We repeatedly ("*saturation effect*") encountered the argument that real-time pricing poses an increased risk for households. This prompted us to measure the willingness to pay (risk premium) of a rational, risk-averse household to exchange the uncertainty of monthly bills from real-time pricing for monthly bills from fixed prices (fixed-price tariff). For typical parameters and multiple household load time series, no risk premium exceeded 1% of household income. In this sense, the risk associated with real-time pricing is negligible and thus contradicts the risks asserted in the discussions.

Methods

To understand real-world barriers of households to switch from fixed price tariffs to flexible pricing models, we conducted systematic discussions involving three key stakeholder groups - energy business experts, energy researchers, and policymakers. These discussions were transcribed and analysed using a sophisticated iterative qualitative coding process (Saldana, 2013) - enabling systematic and objective identification of the core statements from the discussions to critically examine the barriers to dynamic tariff adoption. The method involves structured labelling and organization of themes across expert opinions.

To challenge the findings of the discussions, we determined how a risk-averse rational consumer would evaluate the uncertainty of the monthly real-time pricing bills compared to an "equivalent" fixed-price tariff with its risk premium. In detail, we aggregated a multi-year time series of wholesale prices weighted with synthetic and measured household load to monthly bills and interpreted them as realizations drawn from an unknown distribution of prices (assuming equal probabilities of prices and their independence). We then determined an income-equivalent "average" price - the fixed-price tariff. By comparing the expected utility from the real-time pricing and the fixed-price tariff, we were able to determine the risk premium - that is, a hypothetical transfer that makes a risk-averse household (with constant relative risk aversion) indifferent between being billed monthly based on the uncertain wholesale prices or the certain fixed prices. We repeated this calculation for various consumption[4,5] and

[1] https://octopus.energy/press/largest-electricity-supplier-market-share/?utm_source=chatgpt.com
[2] https://de.statista.com/statistik/daten/studie/1534971/umfrage/umfrage-zur-nutzung-dynamischer-stromtarife/
[3] https://meco.gouvernement.lu/dam-assets/le-ministere/fonctions/energie/electricite/20240731-versorgungssicherheitsbericht-strom-2024.pdf
[4] https://data.open-power-system-data.org/household_data/2020-04-15

corresponding price time series of hourly day-ahead market prices (ENTSO-E) covering the period from 2018 to 2024 in Luxembourg.

Results

Our evaluation of the discussions revealed that the uncertainty associated with fluctuating prices - particularly price peaks - is perceived as a significant barrier to the adoption of real-time pricing. Experts highlighted that consumers' aversion to risk, especially concerning unpredictable monthly billing and occasional price spikes, can constitute a substantial obstacle: "… *Having this part of the energy transition in place coming from the regulation side is, I think, a very relevant one, but it's only helpful if the customers that you are addressing can make use of it. And if they can't, and such a tariff would come on top of their consumption, it would be quite expensive (…)"* - Business Expert. The experts highlight the fear that households, if unable to react to price peaks, would be unprotected against the monetary consequences, which ultimately manifest in their electricity bill. We refer to this as "Peak-to-Bill Anxiety".

To challenge this claim, we found, using the method described in the previous section with a common relative risk aversion coefficient between 2 and 3 (Ljungqvist & Sargent, 2004) for an average monthly net income of €3,540 in Luxembourg[6], that none of the consumption profiles exhibited a risk premium-to-income ratio exceeding 1% - indicating a small discomfort caused by bill fluctuations. In other words, a dynamic tariff does not induce significant uncertainty or create a demand for risk coverage for the average Luxembourgish household. Therefore, we consider the concept of "Peak-to-Bill Anxiety" to be rationally unfounded.

Conclusions

Our findings reveal a discrepancy between the perceived and actual risks associated with dynamic electricity tariffs, which may hinder their adoption despite their significant potential to reduce the costs of the energy transition. Although these tariffs are designed to promote investment and demand-side response such as conservation and load shifting, an exaggerated risk perception, termed "Peak-to-Bill Anxiety," remains a critical barrier. Our empirical analysis indicates that, under the analysed market conditions, households should not perceive dynamic tariffs as substantially riskier than fixed-price tariffs.

However, this may change if price volatility in a de-carbonised system increases significantly. Furthermore, experiences with atypical situations, such as the European gas price spike or the Texas Winter Storm Crisis, show that unmanaged price risks can cause severe economic and social harm, particularly to households exposed to real-time pricing. In these scenarios, real-time pricing could help reduce peak demand and maintain grid stability, but they also transfer extreme price spikes directly to households, thereby increasing financial vulnerability. Anxiety stemming from the fear of these rare events cannot be entirely dismissed as unfounded; it must be assessed in terms of their likelihood and the political willingness to socialize the costs of these crises.

Moreover, real-time pricing may disproportionately burden low-income households, which allocate a higher-than-average share of their income to energy consumption. These households, more exposed to price risks, might be willing to mitigate these risks through asset operation (such as storage), behavioral changes, or the use of financial instruments. However, financing these strategies could be even more challenging for them. Consequently, a flexible electricity price may not be a welfare-enhancing option for these households.

Our findings underscore the necessity for a deeper understanding of the extent and specific reasons behind "Peak-to-Bill Anxiety" to identify ways to mitigate it. This could potentially be achieved through targeted consumer education to distinguish routine price fluctuations from genuine risks. In rare cases, support may also be provided through tools such as automated controls to manage volatility or financial instruments to insure against risks.

References

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