The economics of prosumers

Jean-Christophe Poudou[a], **Axel Gautier**[b], **and Julien Jacqmin**[c], [a]University of Montpellier, MRE, Site Richter, Montpellier, France; [b]HEC Liege, University of Liege, Liege, Belgium; [c]NEOMA Business School, Rouen, France

Abstract

Prosumers are residential consumers who are both producing and consuming electricity. They utilize photovoltaic panels on their rooftops or small wind turbines for production and contribute to the shift towards zero-carbon futures. These small-scale production facilities are connected to the low-voltage grid. Prosumers are making two types of exchanges with the grid, power injection when their production exceeds their consumption and power withdrawal when their consumption exceeds their production. Self-consumption of electricity at the place of production is an important feature of the prosumer's economic problem. It is the main difference between prosumers and utility-based production facilities. The prices set for these power exchanges with the grid affect the economic return of the decentralized installation. Hence, the incentives to become prosumer. Subsidies, peer-effect and decentralized energy trading also affect adoption. Finally, prosumers may adapt their behavior and shift load to better synchronize their consumption with their production but they may also increase their total consumption, a possible "solar rebound effect".

Keywords

Decentralized production; Electricity; Net-metering; Prosumers; Self-consumption; Solar; Solar rebound; Tariffs

Key points

- Prosumer is an economic agent that produces and consumes local or home-made electricity.
- Self-consumption is an important characteristic of prosumers.
- Net metering and net billing are alternative remuneration schemes.
- Public subsidies are incentives to adopt a distributed energy resources system, but peer effects, local trades and energy communities also have an impact.
- Prosumers may adapt and change their consumption of electricity, creating a solar rebound effect.

1 Introduction

In the energy landscape, a new economic actor has emerged: the prosumer. Households are no longer confined to passive roles as electricity consumers, they are now active participants, engaged in both production and consumption of energy. For decentralized production, households mainly used rooftop photovoltaic panels, connected to the low voltage grid. Initially regarded as a marginal phenomenon, they rapidly matured into a mainstream technology, with significant installations worldwide.

https://doi.org/10.1016/B978-0-323-91013-2.00021-6

Understanding the economics of prosumers is crucial to understand their impact on the energy sector and their role in the energy transition. In this chapter, we develop main aspects of the economic analysis of prosumers.

In the second section, we present the concept of prosumer and the main trends in the development of decentralized product units. In Section 3, we discuss the key concept of self-consumption and the integration of prosumers into the wider energy system, which requires a close examination of metering methods, remuneration schemes, and regulatory frameworks. In Section 4, we discuss the remuneration of prosumers, and the two main systems: net metering and net billing. The two systems have distinct implications for investment incentives and grid stability.

In Section 5, we show that the profitability and viability of decentralized production units depend on a variety of factors, including public subsidies, peer effects and local energy trading platforms. These incentives act as catalysts for consumer adoption and investment in renewable energy solutions, enabling progress towards a more resilient and environmentally sustainable energy future. Section 6 discusses the so-called solar rebound and the changes in the prosumers' energy consumption after they installed solar panels.

2 What is a prosumer: Definition and trends

The word prosumer is formed by merging the words producer and consumer. This term describes households that engage in both the production and consumption of electricity. Prosumers invest in a decentralized production unit (DPU) and they self-consume part of the energy they produce. Primarily, this dual role is achievable through the installation of photovoltaic panels on the roof of a house.[1]

These facilities are distributed energy resources (DERs) that refer to electricity supply or demand resources of modest scale that are linked to the low-voltage power grid. These resources typically consist of power generation facilities situated near load centers. Various institutions, including GIEC, the World Bank, the European Commission, and the U.S. Government, view these private investments in renewable generation units as a crucial element toward achieving a zero-carbon future.

Although initially a marginal phenomenon until the early 2010s, rooftop photovoltaic panels have since evolved into a mature technology. According to the IEA PVPS (2023) report, approximately 50% of the 240 GW of PV systems are now installed on residential rooftops, with the remaining portion dedicated to utility-scale investments. This growing interest can be attributed to the declining costs of renewables. From 2010 to 2022, the levelized cost of solar in the U.S. has witnessed a remarkable 90% decrease (Davis et al., 2023).

While the absence of consolidated data makes comparisons tricky, theoretical predictions done by IEA PVPS (2023) indicate how the deployment changes country by country. Based on Fig. 1, we see big differences with several countries like Spain or Greece soon reaching one in five households with rooftop PV. Interestingly some countries not very well known for their sun irradiance like the Netherlands and Germany are also some of the leading nations in PV penetration.

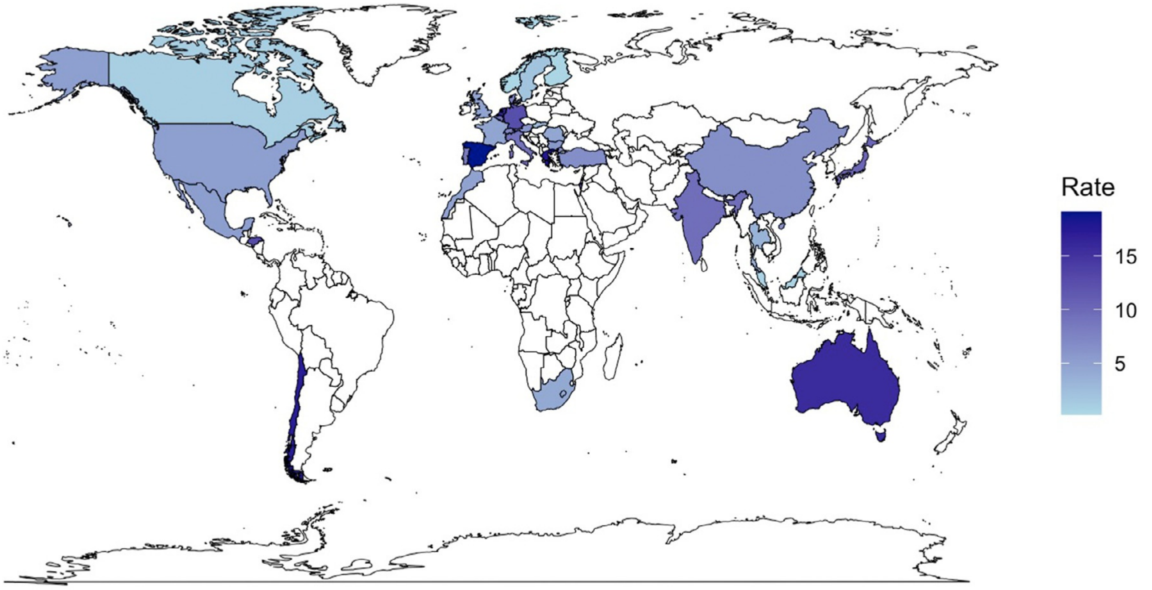

Fig. 1 PV penetration rate worldwide using predictions. Countries in white are missing information. IEA PVPS 2023, Task 1: Strategic PV Analysis and Outreach, Report IEA-PVPS, T1-44. p. 18.

---

[1] Other possible examples of decentralized production units are small wind turbines, battery energy storage systems, but also microturbines and, diesel or natural gas generators. Here we will focus on photovoltaic installations as they are the most common ones.

This emergence of prosumers represents a fundamental change in the dynamics of the electricity system, enabling greater decentralization, democratization of energy production and a greater involvement of consumers in the energy system. It also presents challenges and opportunities for grid operators, policy-makers, and energy companies as they adapt to this evolving landscape. Overall, prosumers play a crucial role in shaping the future of the electricity system towards a more sustainable, resilient, and inclusive model.

While the costs of constructing PV is rather similar worldwide, the value derived by installing them differs across places for several reasons that we will further explore. One first key factor relates to how the prosumers are integrated in the broader energy system. Another essential aspect relates to government subsidies provided to consumers in order to become prosumers. Finally, all consumers are not well informed about the possibilities to become prosumers and peer effects are one important information channel that can explain the boom of rooftop PV.

3 Prosumers in the electricity system

Traditionally, electricity systems operated in a one-way flow, with centralized power plants generating and distributing electricity to consumers. However, technological advancements, particularly in DERs have empowered consumers to generate their electricity. This electricity is either consumed by the prosumer or injected to the grid. Prosumers are making bidirectional exchanges with the grid, they import energy when their production is insufficient to cover their consumption; they export energy when their production exceeds their production. Measuring and pricing these power flows is an important part of the economics of prosumers as it determines the benefits of the decentralized production unit and thereby the incentives to invest.

3.1 Self-consumption, self-production and self-sufficiency

Prosumers produce and consume energy, but production and consumption are not necessarily synchronized. On Fig. 2, we represent a typical daily consumption profile (blue curve) and a daily solar production profile (yellow curve). The two curves do not correspond, at some period, the household's consumption exceeds the solar production. At other periods, the production exceeds the consumption. So only a part of the electricity produced is consumed directly at the place of production. We refer to this as *self-consumption*. The production that is not self-consumed, the solar surplus, is injected to the grid. This corresponds respectively to the pink (self-consumption—Area B) and yellow area (solar surplus—Area A). Finally, the consumption not covered by solar production is imported from the grid (blue area—Area C).

Self-consumption is a distinguishing feature of prosumers. Utility-based power plants do not produce for their own consumption, while prosumers do. We will further show that increasing self-consumption increases the benefit of the DPU i.e. self-consumption is a driving force of investment.

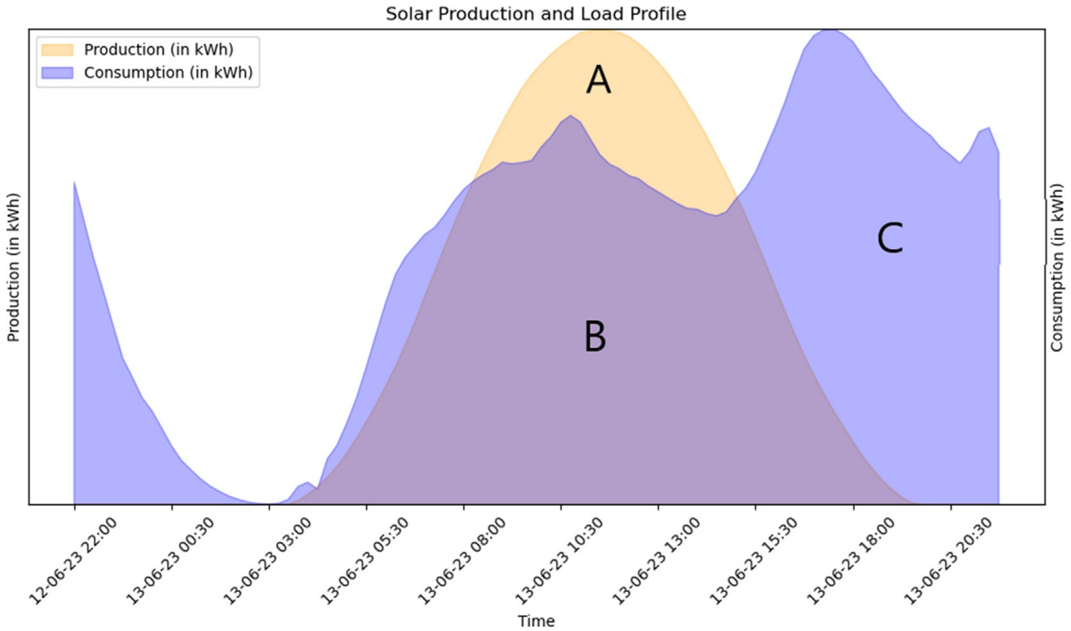

Fig. 2 Daily consumption and solar production profile. Notes: The curves are constructed using the real-load profile curve and the solar production profile curve for a typical summer date (June 13) in Belgium, published by Synergrid (https://www.synergrid.be/).

If we consider a reference period (a day, a month, a year), divided in T time intervals, we denote, at each $t \in 1, 2, \ldots, T$, the solar production by $P(t)$ and the consumption by $C(t)$. The self-consumption $SC(t)$ at period t is measured as $SC(t) = min\{C(t), P(t)\}$. Over the relevant period, the total consumption (C), production (P) and self-consumption (SC) are defined as:

$$C = \sum_{t=1}^{t=T} C(t), P = \sum_{t=1}^{t=T} P(t), SC = \sum_{t=1}^{t=T} SC(t).$$

The solar surplus injected to the grid is equal to $P - SC$.

Given C, P and SC, we define the following ratios:

The self-consumption ratio (ϕ) is the percentage of the production that is self-consumed: $\phi = \frac{SC}{P}$. A higher value of ϕ indicates that the prosumer consumes a larger fraction of its production.

The self-production ratio (ψ) measures the part of the electricity consumption covered by the source of production: $= \frac{C}{P}$.

The self-sufficiency ratio (ω) is the percentage of self-consumption in the total consumption: $\omega = \frac{SC}{C}$.

Estimations of the self-consumption rate vary widely as they depend on the consumption patterns, which are specific and on the size of the installation. According to the studies surveyed by Luthander et al. (2015), for residential households, on average, 35% of electricity generated from solar energy is self-consumed, implying that the majority of the prosumers' solar production is injected to the grid.

The level of self-consumption by a prosumer naturally rises with the installed capacity of the DPU, provided that the consumption pattern remains constant. If the capacity factors remain unchanged, an increased solar capacity won't diminish the overall solar production (P). For a given consumption pattern, this will not decrease the self-consumption (SC). At a given time, once all the consumption is covered by the solar production, an increased production no longer increases self-consumption i.e. at the margin, there are less and less possibilities to consume solar energy. Consequently, the self-consumption exhibits a concave trend, as shown by the blue curve in Fig. 3. A direct consequence is that the rate of self-consumption decreases with the solar capacity: the red curve in Fig. 3.

3.2 Interaction with the grid: Power flows and costs

Consumers, prosumers and centralized production units (CPUs) are connected to the grid which facilitates power exchanges between them. The grid organizes two types of exchanges: distribution of energy from the CPU to the consumption places and distribution of the *excessive* energy production from the DPU to the consumers; Fig. 4 represents these power exchanges.

When a prosumer self-consumes the electricity locally produced at a given period, it bypasses the supplier and decreases its energy bill. The value generated by self-consumption is a saving on the energy bill. When at a period, a prosumer generates an energy surplus, it exports to the grid and can sell the surplus to a supplier, creating a monetary value.

Decentralized production generates additional network costs. The first additional cost of prosumers relates to the technical integration of their decentralized production capacity into the grid. The second is linked to power injection which may cause over-voltage and necessitate to reinforce the low-voltage grid. But there could also be savings, especially if prosumers can decrease their peak-consumption.

Prosumers also have a positive effect on the overall generation costs: increase in production from DER reduces production from CPUs, which are generally more expensive at the margin, as they are based on fossil resources (including a carbon cost). At the end,

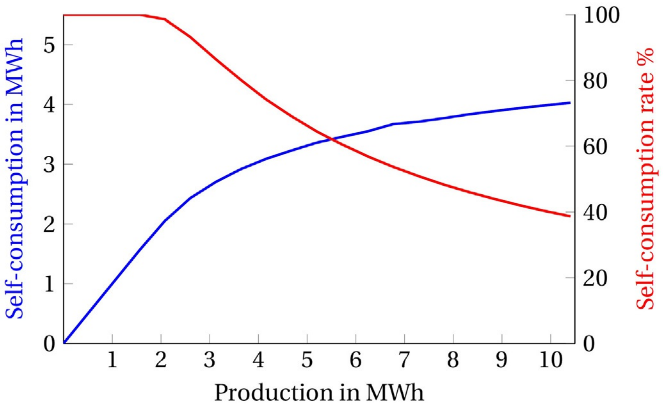

Fig. 3 Self-consumption rate varying with self-production rate. Notes: Data used: yearly self-consumption of a fictive prosumer as a function of its solar production. The yearly consumption is equal to 10MWh and different production capacities, corresponding to a production varying from 0 to 10 MWh per year, are considered. The consumption profile is based on the synthetic load profile (SLP) published by Synergrid for Belgium for the year 2022. We use a synthetic production profile (SPP) for Belgium to convert PV capacity in production from the same source.

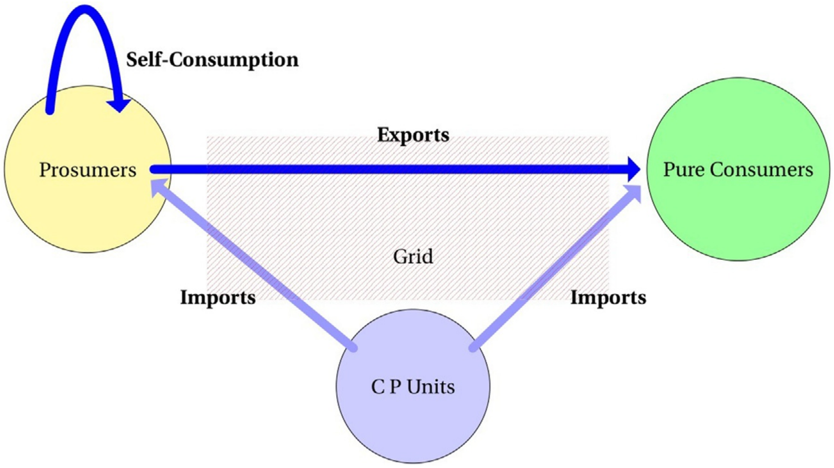

Fig. 4 Power exchanges.

from a social point of view, decentralized energy production should be valued at the marginal cost of centralized generation minus the additional network cost generated by decentralized production.

3.3 Metering methods

Prosumers are equipped with meters and, to recover the power flows depicted on Fig. 4, a prosumer must be equipped with three meters: a production meter to measure its production $P(t)$ at period t and a bidirectional meter to measure the power injection (exports) $P(t)-C(t)$ when $P(t)>C(t)$ and the power withdrawal (imports) $C(t)-P(t)$ when $C(t)>P(t)$. The self-consumption over the period can be recovered from these meter readings as the difference between the production and the exports to the grid. This is what can be typically done with a smart meter. Absent one of these meters, the power flows cannot be reconstructed. For instance, instead of a bidirectional meter, the DPU can be connected to a single mechanical meter that runs backward when the electricity is injected into the grid. In this case, it is impossible to recover the prosumer's self-consumption level.

4 Remuneration for prosumers

4.1 Benefits of a DPU

Given P and C, the meters can record the imports, the exports, and the self-consumption. From that, we can compute the benefit of a DPU. Let us denote by p^m, the retail price of electricity, the price a consumer pays for its imports from the grid and by p^x, the price at which a prosumer sells its surplus to the grid. These prices are composed of the commodity price, the grid fees and the different taxes and surcharges if applicable.

In a simplified model, we can write the private benefit of a solar installation producing P as[2]:

$$B = p^m SC + p^x (P - SC)$$

The first term is the benefit of self-consumption. The self-consumed energy replaces energy from the grid sold at price p^m by retailers, hence SC is the savings associated with self-consumption. The second term is the revenue generated from the sales of the solar surplus to the retailers.[3] At this stage, subsidies that were available in many countries, are not included in the benefit.

Rearranging the terms, we can write the unit benefit per kWh produced as

$$b = \frac{B}{P} = p^x + (p^m - p^x)\phi$$

In this formulation, it is now explicit that the self-consumption rate is a determinant of the benefit of the installation. The benefit increases with the self-consumption level if $p^m > p^x$.

4.2 Net metering and net billing

Two main mechanisms to remunerate the prosumers are net billing and net metering. Under net metering, the export price p^x equals the retail price p^m. All the solar production is valued at the retail price: $B=p^m P$ and $b=p^m$ i.e. the imports $(C-SC)$ and the export

---

[2] A more sophisticated model would include time-varying prices and a discount factor to compute the benefit over the asset's life-cycle.

[3] If there is an injection fee for the exports that the prosumer should pay, we suppose that p^x is the net price received by the prosumer.

($P-SC$) have the same price. As a consequence, the consumer's variable part of the bill is based on the difference between imports and exports, $C-P$. If, over the billing period, the consumption is larger than the solar production, the consumer's bill is equal to $p^m(C-P)$. If, instead, the production is larger than the consumption, the solar surplus can be either transferred to the next billing period (as a credit) or bought back at some pre-specified price, which is usually a fraction $0 \leq \beta < 1$ of the retail price.

With net billing, the retail and the export prices differ: $p^m \neq p^x$. With different prices, the bill is no longer based on the difference between consumption and production, but on the actual electricity exchanges with the grid, exports and imports. With net billing, an increase in self-consumption generates savings equal to $(p^m - p^x)$ which is positive if imports are more costly than exports.

The main criticism that has been addressed to net metering is that the system generates inadequate incentives to invest (Brown and Sappington, 2017a,b; Gautier et al., 2018, 2021). Net metering is not able to align the private and the social cost of investment, resulting in too much investment by prosumers in production. In addition, an increase in self-consumption does not generate any saving on the bill and prosumers do not have incentives to synchronize their consumption with their production. Net billing does not suffer from the same flaws, and it is possible to design network tariffs that are part of the prices p^m and p^x, to align the private incentives with the first best (see Gautier et al., 2018, 2021).

Furthermore, with net metering, the volumetric part of the bill is based on the difference between production and consumption. This implies that the contributions of prosumers to the grid financing is reduced, as some of their exchanges are not subject to grid fees. With reduced revenues for the grid, the operator should increase its fee to recover its cost. However increasing the grid fee increases the retail prices, which further increases the benefit of being a prosumer. Hence, this phenomenon creates financial instability for the grid and is often called the utility death spiral.

Many countries and regions, the Netherlands, Belgium, Austria, Denmark, and Greece, as well as 43 U.S. states, initially adopted net metering as a means to integrate prosumers into the energy system. However, most have since transitioned to a net billing system to ensure sustainable financial resources for the grid operator and more adequate incentives for the prosumers.[4]

4.3 Profitability of a DPU

Suppose that the solar installation producing P kWh has a total installation cost equal to Z. We define the unit cost per kWh produced as $z = \frac{Z}{P}$. The solar installation has a positive return if $B \geq Z$, that is if

$$B \geq Z \Rightarrow p^x + (p^m - p^x)\phi \geq z$$

Under net-billing, if $p^x \leq z \leq p^m$, the installation is profitable only if the self-consumption rate is high enough.

A prosumer can increase its self-consumption rate to increase its installation's benefit. This can be done by shifting the load to synchronize production and consumption better and by buying storage devices like a residential battery or an electric vehicle. Notice that if a prosumer has incentives to increase its self-consumption rate under net billing, it is not the case under net metering as the benefit is independent of the self-consumption rate. A lack of incentives to synchronize consumption may generate extra costs for the grid, as it is not designed for massive injection of electricity on the low-voltage grid.

5 Incentives to adopt a DER system

5.1 Subsidies

As we have shown above, the profitability of the investment depends on the prices p^m and p^x, the self-consumption rate and the investment cost. However, it might well be that market-driven prices are such that $b < z$, the investment is not profitable. To boost adoption, several governments have provided subsidies under different forms for solar adoption.

And indeed, many developed nations have implemented subsidized programs to incentivize households to invest in green energy production. The primary argument is the necessity to mitigate negative environmental impacts caused by existing production units. For instance, the installation of rooftop photovoltaic panels can reduce reliance on carbon-emitting power plants, helping achieve CO_2 reduction targets. Economists also argue that market dynamics may not naturally encourage households to adopt these technologies, especially in the early days when returns on investment were uncertain due to technological risks. Early investors, taking on such risks, could be compensated and provide valuable insights for subsequent investors.

Two categories of support schemes exist, designed with respect to time: those during the initial investment stage ($t = 0$) and those during the production stage ($t > 0$). Investment subsidies reduce the installation cost z, production subsidies increase the benefit b.

Investment stage subsidies are a one-time incentive when households install photovoltaic panels. These subsidies may be lump sums, tied to the PV capacity or cost, and can originate from different government levels—national, regional, or local- and may even take the form of tax deductions. All these schemes are typically facilitated through the public finance system and can be accumulated.

Production subsidies, on the other hand, span the life expectancy of the installation or a duration specified by the governing legislation. Usually, production subsidies are self-containing within the energy system and do not rely on the public finance system. This implies that subsidies are usually financed through additional surcharges on the electricity bill. The two main mechanisms to

---

[4] For the most current information regarding the evolution of legislations about to net metering/billing systems, please refer to the International Energy Agency's website at www.iea.org/policies and the Database of State Incentives for Renewables & Efficiency (DSIRE) at www.dsireusa.org.

subsidize production are the feed-in tariff (or its variant, the feed-in premium) and the green certificates. Assessing the performance of feed-in tariffs and tradable green certificates based on criteria of effectiveness, efficiency, equity and institutional feasibility, Verbruggen and Lauber (2012) conclude that, in practice, feed-in tariff systems perform better than tradable green certificate systems.

In many jurisdictions, the governments over-shooted the support for solar energy and end-up paying subsidies far above the implicit carbon-saving prices (Marcantonini and Ellerman, 2015; De Groote et al., 2024).

One key question is whether it is better to give a subsidy at stage 0 or many subsidies in subsequent stages. The answer depends on how households discount the time value of money. In a paper using PV investment data from Flanders (Belgium), De Groote and Verboven (2019) observe that the implied discount rate is around 15%, which is much larger than the commonly used market interest rate of 3%. Hence, consumers are myopic and production subsidies will tend to encourage less PV investments by households than upfront subsidies, all else being equal. However, they are still in place in many legislations as the burden does not always fall on taxpayers and because it is a way to postpone of payment of the bill to later generations.

5.2 Peer effect

So far, we considered that the motivations for becoming a prosumer were financial i.e. prosumers expect a positive return on their investment. But, the motivations of the prosumers are broader; for instance environmental conscientiousness also play a role (see for example Stikvoort et al., 2020). There is an additional, non-monetary, benefit linked to solar production. In our simple model, we denote this benefit by $\bar{b}$ and, a household will turn prosumer is $b + \bar{b} \geq z$. The literature has shown that this benefit is particularly affected by peer effects.

In economic studies, peer effects encompass various influences among individuals. Following Kandel and Lazear (1992)'s seminal paper, several empirical studies have highlighted the positive peer effects in economic environments other than those of employment relationships. Researchers often distinguish between the influence of a peer's behavior and their characteristics on an individual's decision, as only the former can lead to a social multiplier.

In the case of household investment in solar PV, this peer effect is also prevalent. One interesting aspect is that due to the typically steep rooftop, peers can easily observe installations. In some sense, the private benefit per kWh $\bar{b}$ of a solar installation is enhanced by the peer effect and becomes $\alpha(n)\bar{b}$. Here $\alpha(n) \geq 1$ is the social multiplier that increases with the number n of identified peers. As a result, DPU's are perceived as more profitable as $\alpha(n)\bar{b} + b \geq z$ than without peer effects.

Bollinger and Gillingham (2012) have recognized that social interaction and peer effects are an important factor in the adoption and diffusion of solar PV panels. Using an empirical methodology based on Californian data, they find that at the average number of owner-occupied homes in a given location (they use zip codes), an additional panel installation increases the probability of adoption in same location by 0.78% points.

5.3 Local energy exchange: Peer-to-peer platforms and renewable energy communities

Prosumers can now be part of peer-to-peer exchanges or renewable energy communities. Participation in these trading schemes creates new opportunities to sell the solar surplus, which increases the benefit of being a prosumer and stimulates adoption.

In Europe and the United States, several projects or experiments of peer-to-peer exchange platforms were carried out at the level of neighborhoods or urban islands. The principle behind these platforms is simple: connected prosumers can sell surplus energy or buy the energy needed to a local platform (which they may own). In this type of trading environment, the peer effect is also a factor that multiplies the adoption effect of DPUs.[5]

From an economic point of view, the emergence of P2P electricity trading, facilitated by exchange platforms lays the groundwork for significant societal shifts that can advance the objectives of the energy transition. Rifkin (2011) suggests that Internet technology could facilitate these transformations. According to Mengelkamp et al. (2018), P2P electricity trading could empower small-scale energy consumers and prosumers by fostering investments in local generation and simplifying the development of self-sustainable microgrid communities.

Prosumers participating in a P2P platform can trade their solar surplus with their peers. This may generate additional income for the prosumers if they get a price above the export price p^x. Similarly, in case of shortage, a prosumer can buy from the platform at a price lower than the retail price p^m.

A peer-to-peer marketplace or platform aggregates all consumer demands $D(p)$ and all supplies from occasional sellers $S(p)$. The platform determines a price p^* that clears the local market: $D(p^*) = S(p^*)$. If $p^x \leq p^* \leq p^m$, the platform creates additional value for prosumers. Cortade and Poudou (2022) show that, compared to a no-platform configuration where the excess energy is bought by a default retailer, a pure dealing welfare maximizing platform creates at least as much incentive to install DPUs. P2P platforms may stimulate adoption by prosumers and encourage them to have larger-scale installations.

Renewable energy communities (REC) play the same role and can be a tool to boost solar investment by prosumers. RECs bring together citizens, public administration, SMEs located in the same neighborhood. The REC and its members invest, individually and

---

[5] Soto et al. (2021) proposes a very complete review of the literature about P2P energy trading and provide a summary of P2P trading energy projects.

collectively, in renewable production capacities. The energy produced can be shared and consumed locally by the members: self-consumption becomes *collective*. The REC sells the energy self-consumed at a specific internal price which may induce some benefits for community members and the entire energy system.

The REC is a formal entity that proposes to the m members to buy the energy it produces, or produced by its prosumers' members a discounted price $p^s < p^m$, provided that consumption by the members is synchronized with production. This collectively self-consumed energy is shared between the members according to a pre-specified sharing rule, internally decided within the REC.[6] Per capita, pro-rata total consumption, pro-rata synchronized production or Shapley value-based are often used. Abada et al. (2020) have analyzed these sharing keys in terms of stability criterion and shown that too simple keys destabilize RECs. For a prosumer, participation in a REC can provide additional benefits: the solar surplus can be sold to the community at a higher price than the market and the community can sell electricity at a lower price than the retail price.

5.4 Rebound effect

After installing solar panels on their rooftop, prosumers may adapt their behavior and change how they consume energy. Prosumers may change their load profile to better synchronize their consumption with the solar production. They may also change their total consumption of electricity, a phenomenon referred to as *solar rebound*.

In a nutshell, the relative prices of solar and grid energy are no longer the same, creating incentives to substitute one with the other. In addition, the solar installation may generate net savings for the households, equivalent to an increase in disposable income and may affect consumption. In other words, prosumers face both a substitution and an income effect. Olivier et al. (2023) discusses the microeconomic foundation of the solar rebound effect, covering different institutional contexts.

These changes might be motivated by both environmental and financial concerns. Talking about the latter, for a prosumer, the energy from the grid and the solar energy do not have the same value. If self-consumed, solar energy replaces energy from the grid and it is valued at the retail price p^m. If exported to the grid, the solar energy is valued at the purchasing price p^x. A shift from export to self-consumption creates a net benefit if the purchasing price is below the retail price. Incentives to increase self-consumption are linked to the difference between prices $(p^m - p^x)$. The incentives to shift the load are related to the difference between the retail and purchasing prices. They are, therefore, context-specific and they depend on the regulation in place.

Prosumers may consume more of the relatively cheaper solar electricity and less electricity from the grid, but the substitution may not be one-to-one. In addition, solar modules may increase the household's available income. For these reasons, the total consumption may be different after the PV installation.

Several papers have analyzed empirically the prosumers' consumption behavior. Studies could be based on survey or meter data. The literature documents both an increase in self-consumption and on total consumption, and there is significant evidence of a rebound effect, with a total consumption increasing up to 20%.[7]

6 Conclusion

Prosumers, individuals who both consume and produce energy, are pivotal actors in addressing the diverse challenges and capitalizing on the opportunities within today's energy landscape. Self-consumption initiatives are designed to engage citizens in the energy transition process actively, thereby making substantial strides towards achieving the environmental objectives that societies have established.

The economics of prosumers hinges upon two fundamental pillars. Firstly, it relies on prosumers' capacity to integrate into the overarching seamlessly energy system, thereby fostering conditions conducive to equitable compensation while minimizing supplementary costs for electricity distribution networks. This integration necessitates the development of frameworks that facilitate the smooth incorporation of prosumer-generated energy into the broader grid infrastructure, ensuring fair compensation mechanisms that account for both the energy supplied and consumed. In particular, grid fees for the exchanges between prosumers and the grid should be carefully designed.

Secondly, the sustainability of prosumer economics depends on the presence of incentive structures designed to spur investment in Distributed Energy Resources (DERs). Such incentives can take the form of public support programs aimed at subsidizing the initial costs associated with adopting DER technologies. Moreover, the creation of private and social value derived from self-consumption activities serves as a potent motivator for prosumers to invest in renewable energy solutions. By recognizing and incentivizing the inherent benefits of self-consumption, whether through reduced reliance on centralized energy sources or the mitigation of environmental externalities, societies can foster a conducive environment for the proliferation of prosumer-driven energy initiatives.

In essence, the viability and effectiveness of prosumers in the energy sector necessitates a dual approach that not only facilitates seamless integration into existing energy frameworks but also incentivizes proactive investment in sustainable energy solutions. Through strategic policy interventions and the cultivation of supportive regulatory environments, stakeholders can harness the transformative potential of prosumer participation, thereby accelerating progress toward a more resilient, equitable and environmentally sustainable energy future.

---

[6] See Gautier et al. (2023) on the economics of energy communities.

[7] See for example Wittenberg and Matthies, (2016), Deng and Newton (2017), Qiu et al. (2019), Boccard and Gautier (2021) and Aydin et al. (2023).

References

Abada I, Ehrenmann A, and Lambin X (2020) On the viability of energy communities. *Energy Journal* 41(1): 113–150.

Aydin A, Brounen D, and Ergn A (2023) The rebound effect of solar panel adoption: Evidence from Dutch households. *Energy Economics* 120: 106645.

Boccard N and Gautier A (2021) Solar Rebound: The unintended consequences of subsidies. *Energy Economics* 100: 105334.

Bollinger B and Gillingham K (2012) Peer effects in the diffusion of solar photovoltaic panels. *Marketing Science* 31(6): 900–912.

Brown DP and Sappington D (2017a) Optimal policies to promote efficient distributed generation of electricity. *Journal of Regulatory Economics* 52(2): 159–188.

Brown DP and Sappington D (2017b) Designing compensation for distributed solar generation: Is net metering ever optimal? *Energy Journal* 38(3): 1–32.

Cortade T and Poudou J-C (2022) Peer-to-peer energy platforms: Incentives for prosuming. *Energy Economics* 109. 105924.

Davis LW, Hausman C, and Rose NL (2023) Transmission Impossible? Prospects for Decarbonizing the US Grid. *The Journal of Economic Perspectives* 37(4): 155–180. Fall.

De Groote O and Verboven F (2019) Subsidies and time discounting in new technology adoption: Evidence from solar photovoltaic systems. *American Economic Review* 109(6): 2137–2172.

De Groote O, Gautier A, and Verboven F (2024) The political economy of financing climate policy - Evidence from the solar PV subsidy programs. *Resource and Energy Economics* 101436.

Deng G and Newton P (2017) Assessing the impact of solar pv on domestic electricity consumption: Exploring the prospect of rebound effects. *Energy Policy* 110: 313–324.

Gautier A, Jacqmin J, and Poudou J-C (2018) The prosumers and the grid. *Journal of Regulatory Economics* 53: 100–126.

Gautier A, Jacqmin J, and Poudou J-C (2021) Optimal grid tariffs with heterogeneous prosumers. *Utilities Policy* 68: 101140.

Gautier A, Jacqmin J, and Poudou J-C (2023) *The Energy Community and the Grid*. CESifo Working Paper Series 10254, CESifo.

IEA PVPS (2023) *Task 1: Strategic PV analysis and outreach*. Report IEA-PVPS, T1-44.

Kandel E and Lazear EP (1992) Peer pressure and partnerships. *Journal of Political Economy* 100(4): 801–817.

Luthander R, Widén J, Nilsson D, and Palm J (2015) Photovoltaic self-consumption in buildings: A review. *Applied Energy* 142: 80–94.

Marcantonini C and Ellerman D (2015) The implicit carbon price of renewable energy incentives in Germany. *Energy Journal* 36: 205–239.

Mengelkamp E, Gärttner J, Rock K, Kessler S, Orsini L, and Weinhardt C (2018) Designing microgrid energy markets: A case study: The Brooklyn Microgrid. *Applied Energy* 210: 870–880.

Olivier M, Moreno-Cruz J, and Gillingham K (2023) *Microeconomics of the Solar Rebound Under Net Metering*. USAEE Working Paper No. 23-588.

Qiu Y, Kahn ME, and Xing B (2019) Quantifying the rebound effects of residential solar panel adoption. *Journal of Environmental Economics and Management* 96: 310–341.

Rifkin J (2011) *The Third Industrial Revolution; How Lateral Power is Transforming Energy, the Economy, and the World*. Palgrave MacMillan.

Soto EA, Bosman LB, Wollega E, and Leon-Salas WD (2021) Peer-to-peer energy trading: A review of the literature. *Applied Energy* 283: 116268.

Stikvoort B, Bartusch C, and Juslin P (2020) Different strokes for different folks? Comparing pro-environmental intentions between electricity consumers and solar prosumers in Sweden. *Energy Research & Social Science* 69: 101552.

Verbruggen A and Lauber V (2012) Assessing the performance of renewable electricity support instruments. *Energy Policy* 45: 635–644.

Wittenberg I and Matthies E (2016) Solar policy and practice in Germany: How do residential households with solar panels use electricity? *Energy Research & Social Science* 21: 199–211.