EXAMPLES OF INNOVATIVE FINANCING SCHEMES

2025

EurObserv'ER

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Examples of innovative financing schemes

CASE STUDIES
INNOVATIVE FINANCING SCHEMES

Under the current macro-economic trends, the so far abundant support system for renewables (mainly in the form of feed-in tariffs and quota systems) has been drastically modified. In many EU countries, companies are trying to find alternative ways to secure financing for their renew - able energy projects. Therefore, new ways of attracting private capital for the realisation of green energy goals have to replace the historical public schemes.

The European Green Deal of the EU requires further, enormous investments in demonstration projects and new storage and flexibility technologies, besides generation facilities. In addition, the energy transition will only become a success, if citizens participate. The challenge is to identify the appropriate policy options and financial tools to attract and scale-up private investments. There are, however, already innovative and promising business and financial models to promote the deployment of RES in the EU.

The aim of the EurObserv'ER case studies is to find such examples and describe them so as to put forward the best practices and the replicability of the future promising financing mechanisms. The selection criteria for the choice of case studies should ensure diversity across regions and RES, diversity across finance instruments/mechanisms, success of approach and its potential to be replicated and a wide range of the "size" of actors/investors and the resulting RES investments (capacity).

The current selection also takes into account the fact that there were already some case studies published in 2014, 2015, 2018, 2019, 2020, 2022, 2023, and 2024.

These are also available for download on the project website: www.eurobserv-er.org

EMPOWERING CITIZENS TO DECARBONISE THE HEATING SECTOR

THE CHALLENGE OF DECARBONISING THE HEATING SECTOR

Heating accounts for a significant share of energy consumption and greenhouse gas emissions across Europe, particularly in buildings and industry. Decarbonising this sector is critical to achieving national and EU climate goals, yet it remains one of the most complex transitions due to factors like high infrastructure costs, technological lock-in to fossil fuel systems and technologies, and the long life cycles of assets like gas and oil boilers, among others.

Municipalities are at the forefront of implementing the heating transition, retrofitting their buildings, deploying district heating networks, and integrating renewable heat sources like geothermal energy, biomass, or large-scale heat pumps. However, financing these efforts can be challenging. Local authorities often face tight budgets, limited borrowing capacity, and lack of technical expertise. Moreover, heating infrastructure involves long investment cycles and requires cross-sector coordination and multi-stakeholder involvement, further complicating project developments (Martínez et al., 2022).

In response, innovative financing models have emerged in various European countries. This case study explores two such models – KommuneKredit from Denmark and SemOp from France – that offer different approaches to fund municipal investment activities, such as in heating infrastructure. Each model illustrates a different pathway to mobilise capital, manage risks, and ensure public value. Both cases offer valuable learnings on how other countries can implement similar approaches [1].

CASE 1: KOMMUNEKREDIT – CENTRALISED FINANCING FOR DANISH MUNICIPALITIES

KommuneKredit, the Danish credit association for local and regional authorities, was established over 125 years ago to support municipal investment in Denmark. Until March 2025, it functioned as a centralised financial intermediary, issuing bonds on global capital markets and channelling the proceeds to Danish municipalities and other local actors. These entities, which acted as borrowers, receive loans or lease agreements to finance infrastructure investments such as district heating systems. As of March 2025, KommuneKredit no longer raises capital on the global financial markets itself through the issuance of bonds, but receives all financing from the Danish state. The state obtains capital on the market even more cheaply than KommuneKredit, and ultimately guarantees the loans of KommuneKredit.

Clients of KommuneKredit are the 98 Danish municipalities, five regions, and other local actors benefitting from a 100% local government guarantee. The agency benefits from the joint liability of all municipalities and a statutory requirement obligating the national government to ensure municipal solvency. This arrangement significantly reduces the credit risk associated with municipal loans.

The financial products offered by KommuneKredit are loans and financial leasing. These instruments provide municipalities with flexible and low-cost financing. The process involves a robust due diligence procedure that ensures compliance with all relevant regulations.

The high rating of KommuneKredit is built on government backing. This effectively eliminates the default risk, making it a very secure financing construct. This also allows for funding to be strategically diversified across a broad spectrum of markets, investors and products, reducing reliance on any single source. The dual role of municipalities, as both borrowers and co-owners of the institution, ensures strong governance and responsible financial decisions.

The primary advantages of KommuneKredit lie in its ability to provide affordable capital to municipalities in need, its streamlined administrative processes, and its long-standing expertise and experience in public financing. However, the model's success also depends on centralised governance and strong inter-municipal solidarity, which may be difficult to replicate in countries with different federal, legal, and administrative structures.

1. It is, however, important to note that both financing models do not only work for financing innovative activities in the heating sector, but can also be applied to other investment needs. However, use in the past has shown that both the KommuneKredit and the SemOp model are especially well-suited for complex, large-scale, and long-term undertakings such as the decarbonisation of heating.

ANNA BILLERBECK, FRAUNHOFER ISI

Pipes for district heating in Denmark

CASE 2: SEMOP – PUBLIC-PRIVATE PARTNERSHIP FOR TARGETED PROJECTS IN FRANCE

Started over a decade ago, the French "Société Économique Mixte à Opération Unique" (referred to as “SemOp”) represents a legal and organisational innovation for executing public infrastructure projects. Unlike KommuneKredit's centralised approach, SemOp is based on the formation of a project-specific joint venture between a municipality and one or more private partners. These partnerships are designed for a single purpose, such as developing a specific district heating network, and exist only for the duration of that particular project.

Within this structure, the municipality maintains a controlling minority share, while the private sector provides the remaining capital along with technical expertise. This arrangement enables municipalities to retain strategic decision-making power while benefiting from the capital and know-how of private operators. The legal form of a joint-stock company ensures that the private partners are economically incentivised to deliver results, where performance is monitored through periodic evaluations. At the end of

the project term, typically several decades, the municipality may choose to re-tender the contract.
The SemOp entity raises equity from both public and private stakeholders and may also secure debt financing from banks under market conditions. Financial risk is limited to the capital invested by each shareholder, while debt providers manage their exposure through credit assessments and collateral arrangements.
Advantages of the SemOp model include its capacity to mobilise private capital, reduce administrative burdens typically associated with concession contracts, and maintain public oversight. However, it also entails additional transactions and introduces complexity through the need to establish a new legal entity and manage contractual and evaluation processes. Additionally, the time-limited nature of the partnership can result in discontinuities, even when a project is operating successfully.
Table 1 presents and compares the two examples – KommuneKredit from Denmark and SemOp from France – highlighting key features.

Tabl. 1

Comparison of financing models

Feature	KommuneKredit	SemOp
Model Type	Public financial agency / intermediary	Public-private partnership
Primary Goal	Low-cost capital for municipal infrastructure	Joint execution of specific municipal infrastructure projects with private sector
Capital Source	Financing through bonds via the central government	Equity from public and private partners, plus bank loans
Municipal Role	Sole borrower, full joint liability among municipalities for bonds	Strategic minority shareholder in a joint venture
Private Sector Role	No direct role (investors buy bonds indirectly)	Provides capital and technical expertise directly
Project Scope	Large-scale municipal developments	Specific time-bound projects
Final Borrower	Municipality	Public-private partnership
Risk Handling	Government guarantee, diversification of investor and markets	Risk sharing, performance evaluation of private partner
Legal Complexity	Low (centralised model)	High (requires legal entity, contracts, evaluations, and distinct processes)
Control Mechanism	Centralised due diligence and oversight	Public partner holds blocking minority and oversight rights
Contract Duration	Ongoing lending (not project-specific)	Time-bound to the project duration (can last several decades, depending on the project)

RECOMMENDATIONS FOR BROADER APPLICATION AND REPLICATION

The presented approaches, tailored to national, legal, and institutional conditions, can significantly enhance the financial viability and governance of the heating transition, helping Europe achieve its climate and energy targets at the local level. While it will not be possible to “copy and paste” either of the two models to another country, EU Member States may explore elements of the KommuneKredit and SemOp models to be adapted and incorporated into their own national frameworks, e.g. through regulatory sandboxing approaches to test replicability.
Countries aiming to accelerate the heating transition and mobilising large volumes of capital could consider developing public financing institutions modelled after KommuneKredit. These institutions could issue green bonds or other debt instruments to pool capital for municipal investments, with credit guarantees or loss-sharing mechanisms provided by central or regional authorities. Such institutions could help level the playing field, especially for smaller municipalities that may find it difficult to access capital markets directly.
Alternatively, countries aiming for specific local projects and including private actors may benefit from enabling municipalities and other actors to create time-bound, project-specific joint ventures with private actors, as portraited in the SemOp model. These partnerships can ensure efficient implementation and performance accountability, particularly for complex infrastructure investments like district heating networks.
Furthermore, both models provide some interesting approaches on how to mobilise capital and enable complex system change needed for transforming the heating sector. First, KommuneKredit show that coordination is essential and that national, regional, and local actors must work hand-in-hand to enable the heating transition. Second, public administrations benefit from cooperation with private actors, as this fosters capacity-building for municipal officials and mobilises further private capital to enable transition to happen where it is needed and avoid top-down approaches. Third, both models demonstrate the need for strong multi-level, private and public collaboration for long-term policy stability, as well as for clear framework conditions to foster trust and help to mobilise much needed capital. ▫

KOMMUNEKREDIT

REFERENCES

- *Martínez, Sara Herreras; Harmsen, Robert; Menkveld, Marijke; Faaij, André and Kramer, Gert Jan: Municipalities as key actors in the heat transition to decarbonise buildings: Experiences from local planning and implementation in a learning context, Energy Policy Volume 169, 2022; https://doi.org/10.1016/j.enpol.2022.113169*
- *KommuneKredit: Transition of KommuneKredit funding – outstanding bonds remain unaffected; https://www.kommunekredit.com/*
- *Cerema (2021): La société d’économie mixte à opération unique (SEMOP); https://outil2amenagement.cerema.fr/outils/la-societe-deconomie-mixte-operation-unique-semop*
- *Légifrance: Code général des collectivités territoriales; https://www.legifrance.gouv.fr/codes/section_lc/LEGITEXT000006070633/LEGISCTA000029178088/*
- *Deutsch-Französische Zukunftswerkstatt (2024): Das französische Betreibermodell SEMOP für Wärmenetze; https://df-zukunftswerk.eu/sites/default/files/medias/file/2024/12/DE_Factsheet%20Semop_1.pdf*

GREEN BONDS IN CENTRAL AND EASTERN EUROPE: MOMENTUM, CHALLENGES AND THE ROAD AHEAD

GREEN BONDS AS A CORNERSTONE OF THE LOW-CARBON TRANSITION

Green bonds are fixed-income instruments designed specifically to support projects and activities that deliver environmental benefits, e.g. in renewable energy, energy efficiency, or climate change mitigation and adaptation. In their structure and mechanics, they mirror traditional bonds but distinguish themselves through the commitment to use the proceeds exclusively for "green" projects, as well as being subject to specific criteria, reviews or certifications. In the EU, for instance, the Taxonomy Regulation (Regulation (EU) 2020/852) establishes the standard for activities which can be considered as green and sustainable. Specifically, Annex I of the Delegated Regulation (EU) 2021/2139 sets out the technical screening criteria for activities falling within that realm. These are regularly reviewed and amended in light of scientific and technological developments.

Energy, in particular renewables, grid modernisation, and energy efficiency investments, absorb the largest share of global proceeds from green bonds. This predominance reflects the sector's vast capital requirements. Against this backdrop, green bonds have emerged as one of the most effective channels for mobilising private and public capital into energy transition projects (Sobik, 2023).

CURRENT SITUATION AND GREEN BOND INVESTMENT TRENDS IN THE EUROPEAN UNION

Under the European Green Deal, green bonds are vital for financing the shift toward a low-carbon economy. Since their market debut, they have emerged as a cornerstone in the transition toward sustainable finance and the European Union (EU) is taking a leading role in their issuance and standardization (EEA, 2024).

In Western European countries, green bonds have seen sustained growth in recent years. The stock of government-issued green bonds reached €266 billion across the EU by end 2022, roughly 1.7 % of EU GDP, nearly triple the level recorded in 2019 (€85 billion / 0.6 % GDP). France and Germany dominate this landscape, holding about €95 billion and €63 billion respectively, together accounting for nearly 60 % of the total outstanding EU green debt. Green bonds also rose significantly in relation to total bonds issued. Notably, in countries like Denmark, Sweden, and Finland, green bonds composed over 16% of all bonds issued in 2023 (Eurostat, 2023).

As seen in Table 1, Western European countries dominate green bond issuance relative to debt growth, with countries like Sweden, Luxembourg, Denmark, the Netherlands, and Ireland showing green bond issuance accounting for over 20% of the change in gross debt. By contrast, Central and Eastern European (CEE) countries lag significantly behind. For instance, Poland and Lithuania issued green bonds amounting to 2.1% and 0.5% of the change in gross debt respectively, more than ten times lower than the leading Western countries. Hungary, Latvia and Slovenia are exceptions within the CEE and Baltic region, showing relatively stronger performance at 9.1%, 11.6% and 13.8%, respectively, approaching the lower range of Western European countries like Austria and Spain.

Green bonds can also be classified based on the issuing entity, e.g. national governments, sub-national governments such as local or regional governments, corporates, or financial institutions. Figure 1 shows the concentration of green bond issuance at the central government level across the EU, with an average of 1.2% of GDP compared to just 0.3% for state governments and 0.2% for local governments. While countries like Belgium, Spain, and Germany show a more layered approach to public green financing with considerable activity by state governments, activity is limited to central governments in CEE countries. France is unique in its relatively high local government participation in green bonds, with volumes corresponding to 1.3% of GDP issued at the local level.

Wind farm near Koszwały, Poland

Tabl. 1

New issuance of green bonds, cumulated 2019-2022

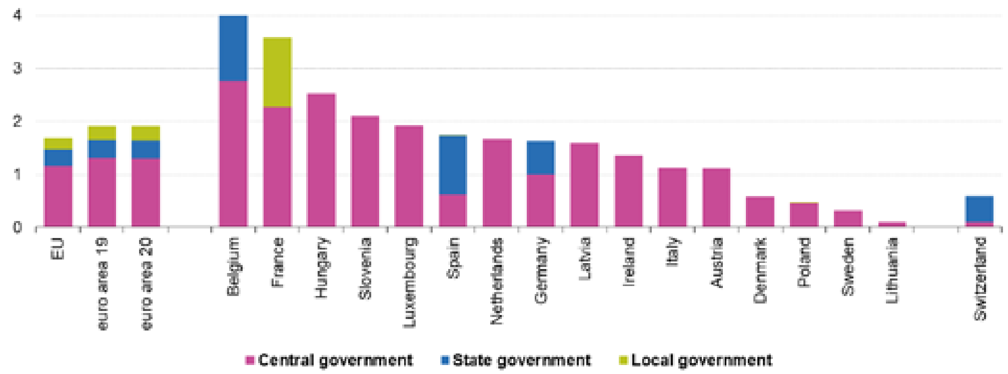
Country	Issuance of green bonds as a percentage of change in gross debt	Issuance of green bonds as a percentage of change in stocks of debt securities
Sweden	42,5	-10,7
Luxembourg	22,5	20,0
Denmark	21,5	20,1
Netherlands	21,1	27,4
Ireland	20,4	21,7
Belgium	14,5	17,4
Slovenia	13,8	15,8
Germany	11,9	15,7
Latvia	11,6	11,5
France	11,0	12,3
Hungary	9,1	9,8
Austria	7,7	9,5
Spain	7,2	7,5
Italy	5,7	6,9
Poland	2,1	3,2
Lithuania	0,5	0,6

FIGURE 1 STOCKS OF GREEN BONDS BY ISSUING MEMBER STATE, END OF 2022

That said, the CEE region has been historically slower in adopting green financial instruments and remains at an earlier stage of development when it comes to green bonds. As of late 2022, several CEE countries, including Bulgaria, Czechia, Romania, Slovakia, and others, had not yet issued any (government) green bonds. Where issuance exists, such as in Hungary, Slovenia and Poland, volumes remain modest compared to Western Europe. However, the region is showing growing interest and activity. More and more CEE countries are entering the green bond market or are preparing their entry, with regulatory frameworks emerging and/or solidifying. While green bond activity in Poland and Hungary has been primarily concentrated in the government sector, corporate and financial institutions are also active in other CEE countries. Table 2 provides an overview of recent and emerging developments across several countries.

Grap. 1

Stocks of green bonds by issuing Member State, end of 2022, (% of national GDP)



Source: Eurostat, 2023

Tabl. 2

Notable issuance of green bonds in CEE countries (overview)

Country	First Green Bond Issuance	Issuer Type	Maturity Date	Eligible expenditures
Poland	2016	Sovereign	2021	Focus on sustainable agricultural operations, clean transportation, and renewable energy
Hungary	2020	Sovereign	2027-2035	Focus on renewable energy, energy efficiency, land use and living natural resources, waste and water management, clean transportation, and adaptation
Czechia	2022	Corporate, financial	Varies	Focus on energy and transport
Romania	2024	Sovereign	2031-2036	Focus on clean transportation, water management, and energy efficiency
Bulgaria	Pending	Corporate, financial	n/a	To be determined

CEE countries still lag behind Western Europe, where markets like France, Germany, and the Netherlands issue billions of Euros in green debt annually. However, with new frameworks and strategic shifts in countries like Romania and Bulgaria, the region is starting to narrow the gap. The following sections give an overview of newer developments in selected CEE countries.

POLAND: THE FIRST MOVER

Poland made history in 2016 by becoming the first country to issue a sovereign green bond. Since then, it has successfully launched multiple tranches, raising over €6 billion. The Polish Green Bond Framework aligns with the Green Bond Principles of the International Capital Market Association (ICMA) and funds projects in renewable energy, sustainable agriculture, and climate-resilient infrastructure, amongst others. According to Poland's Ministry of Finance, the proceeds have been used for projects such as afforestation and rail modernisation. Poland's approach to green bonds has attracted institutional investors and established a role model for sovereign issuers across the CEE region (Ministry of Finance of Poland, 2017).

HUNGARY: EARLY ISSUER WITH EU ALIGNMENT

Following in Poland's footsteps, Hungary entered the sovereign green bond market in 2020 by issuing a €1.5 billion green bond with a maturity in 2025, followed by subsequent issuances aligned with the EU Green Bond Standard. The Hungarian Debt Management Agency (ÁKK) has developed a green bond framework to finance projects in areas such as renewable energy, clean transportation, and waste management. Hungary's green bond programme is part of its broader climate strategy and is supported by annual reporting on environmental impact and use of

Miejska Górka wind farm in Poland

NORDEX SE

proceeds (ÁKK, 2023). Despite market volatility, Hungary remains one of the most active sovereign green bond issuers in CEE.

ROMANIA: A NEW ENTRANT WITH STRONG INSTITUTIONAL BACKING

Romania launched its inaugural sovereign green bond framework in February 2024. The Ministry of Finance of Romania published detailed documentation, including a second-party opinion and allocation criteria consistent with EU standards, promoting trust from investors and a considerable oversubscription. According to the Romanian Investor Presentation (Ministry of Finance of Romania, 2023) and the World Bank technical case study (World Bank, 2025), key eligible sectors included clean transport, sustainable water use, and green energy.

Romania aims to further deepen investor confidence through transparency and adherence to EU rules. Notably, this move aligns with broader EU initiatives under the InvestEU programme, increasing Romania's visibility in international capital markets.

BULGARIA: THE "NEW KID ON THE BLOCK"

Although Bulgaria has not yet issued a sovereign green bond, momentum is building in the country. The government is examining policy and regulatory frameworks to facilitate issuance. Financial institutions, such as First Investment Bank (FIBank), are also weighing inaugural green bonds (SeeNews, 2023).

The European Bank for Reconstruction and Development (EBRD) is playing an important role through technical assistance and programmes, such as InvestEU, to support financial sector decarbonisation (EBRD, 2025).

A GROWING BUT UNEVENLY DISTRIBUTED TREND

While Poland and Hungary serve as more mature, proven issuing countries, Romania and Bulgaria exemplify the growing institutional and financial readiness across the region. Enhanced regulatory frameworks, EU support, and market interest suggest that green bond issuance in CEE will accelerate in the coming years.

However, challenges remain. Market depth, investor familiarity, and capacity building over the coming years will be critical for green bonds to set foot in the region. By continuing to align with EU standards and leveraging international financial institutions, CEE countries can bridge the green finance gap and contribute meaningfully to the EU's climate neutrality goals. ◻

REFERENCES

- *Sobik, Bartosz (2023): Green bonds - financial innovation for sustainability financing: The case of the Polish green bonds market and their development barriers; https://sciendo.com/article/10.2478/ceej-2023-0017*
- *European Environment Agency EEA (2024): Green bonds in Europe; https://www.eea.europa.eu/en/analysis/indicators/green-bonds-8th-eap?activeAccordion=546a7c35-9188-4d23-94ee-005d97c26f2b*
- *Eurostat (2023): Green and sustainability bonds issued by governments; https://ec.europa.eu/eurostat/statistics-explained/index.php?oldid=608684*
- *Ministry of Finance of Poland (2017): Green Bond Report on the Use of Proceeds; https://www.gov.pl/documents/1079560/1080340/Green_Bond_Report_on_the_Use_of_Proceeds.pdf*
- *Hungarian Debt Management Agency ÁKK (2023): Integrated Report on the Allocation and Environmental Impact of Hungary's Green Bond Proceeds, 2022; https://www.akk.hu/download?path=dfeac66d-8d20-4b55-94f2-f974cd9196fb.pdf*
- *Ministry of Finance of Romania (2023): Investor Presentation on Sovereign Green Bond Framework; https://www.mfinante.gov.ro/static/10/Mfp/trezorerie/Romania-ESGInvestorPresentation.pdf*
- *World Bank (2025): Romania Sovereign Green Bond: Financing a Green Transition; https://thedocs.worldbank.org/en/doc/ee9ef873ff97db4156da749dc23abbd1-0340012024/original/Case-Study-Romania-green-bond-TA.pdf*
- *SeeNews (2023): Bulgaria's FIBank weighs up inaugural €300 mln green bond; https://seenews.com/news/bulgarias-fibank-weighs-up-inaugural-300-mln-euro-green-bond-1235628*
- *EBRD (2025): EBRD launches InvestEU programme in Bulgaria's financial sector; https://www.ebrd.com/home/news-and-events/news/2025/ebrd-launches-investeu-programme-in-bulgaria-s-financial-sector-.html*

NEGATIVE ELECTRICITY PRICES IMPACTING BUSINESS CASE AND FINANCING OF RENEWABLES WITH VARIABLE SUPPLY

PV pannels in Germany

MICHAEL FORTSCH

In recent years, the installed electrical capacity of solar and wind energy in the Netherlands has increased significantly. Photovoltaic solar energy (solar PV) grew from 90 MWp in 2010 to 24 GWp in 2024. Onshore wind grew from 2 GW in 2010 to 7 GW in 2024 and offshore wind from 228 MW in 2010 to 4.7 GW in 2024. In total, 35 GW of renewable electricity generation capacity is installed in the Netherlands, with a combined net electricity production of 54 TWh in 2024, approximately 44% of the total gross final electricity consumption of 122 TWh in 2023.

With an increasing weather-dependent supply from solar and wind, which receives suboptimal dispatch incentives due to the support scheme, i.e. to maximize production rather than its system value, the chance that supply exceeds demand has increased. As a result, there is a surplus of electricity on the market, which causes negative electricity prices. The number of hours with negative electricity prices has significantly increased in recent years. In 2020, 2021, and 2022 the annual number of hours with negative prices was less than 50. In 2023, this amounted to a total of 316 hours and for 2024 a total of 465. The Dutch Solar PV Monitor 2024 expresses the expectation that the still increasing electricity from variable renewable energy sources and the possibly decreasing export opportunities to surrounding countries may cause the number of negative price hours to increase even more in the future. At the same time, it is envisaged that electrification of industry, mobility, and other sectors will continue, as well as the uptake of flexibility options such as storage, demand response, renewable electricity curtailment, and interconnection capacity in response to increasing price variability. Both developments would limit the number of negative price hours in the medium-term.

The number of hours with negative electricity prices cannot easily be translated into missed electricity from solar and wind production units. The loss of income depends on the potential production in that hour, which can be different for wind energy than for solar PV. For example: an hour with a negative price during a windy night has no impact on the number of full-load hours for solar PV. The Netherlands Environmental Assessment Agency (PBL) made an estimate for a one-year period during 2023/2024: it was estimated that almost 500 hours with a negative electricity price will lead, specifically for this period, to a number of missed full-load hours of almost 230 for solar PV and of approximately 300 for wind energy. The impact on the business case is larger for solar PV than for wind, since the number of full load hours of solar PV is much lower than for wind, thereby increasing the relative share of missed full-load hours. Due to the increasing number of hours with a negative electricity price and therefore no feed-in premium, solar PV and wind energy projects are receiving less production subsidy than envisaged at the start of these projects leading to concerns are rising about their bankability. Apart from hours with negative prices, the lower capture prices of solar PV and wind energy in the Netherlands are compensated by the SDE++ subsidy through a lower corrective amount and therefore higher subsidies. For more background, see the text box.

For the design of the SDE++, PBL provides annual advice to the Ministry of Climate and Green Growth (KGG). In its advice from February 2025, various measures are mentioned to reduce or mitigate the impact of the high number of hours with negative electricity prices on the business cases of solar PV and wind projects. In her letter to the Second House of 6 June 2025, the Minister of KGG stated that she would not opt for compensatory measures. The measures proposed by PBL are listed below for the sake of completeness, as inspiration for the design of other

Vertical Bifacial PV panels in Germany

MICHAEL FORTSCH

Support scheme SDE++ in the Netherlands

The Dutch Sustainable Energy Production and Climate Transition Incentive Scheme (SDE++) provides a feed-in premium to companies and non-profit organisations that generate renewable energy or reduce CO_2 emissions on a large scale. Among many others, solar photovoltaics (PV) and wind power technologies are supported. The SDE++ is an operating subsidy, available during the operating period of the project. Solar PV and wind power are both subsidised for 15 years. The budget for SDE++ is collected from all electricity consumers and then allocated to projects that apply for an SDE++ subsidy. The total budget for the complete scheme (all technologies) usually ranges from 5 to 12 billion euro in each subsidy round (this amount refers to the reservation for the full 15 years). The core feature of SDE++ is to subsidise the unprofitable component of each technology. The unprofitable component is the difference between the cost of the technology that reduces CO_2 (the 'base rate') and the market value of the 'product' that is generated by the technology (the 'corrective amount'). For solar PV and wind power, the product is electricity, but likewise, for thermal energy, renewable gas and avoided CO_2 are subsidised products. The base rate [€/kWh] is fixed for the entire subsidy period, but the corrective amount [€/kWh] is set annually. The unprofitable component decreases when the market value of the product (i.e. electricity) rises, as does the amount of the subsidy received. In the corrective amount profile losses are considered through a profile factor(and up to SDE++ 2024 also imbalance costs). This means that the corrective amount takes into account that lower prices occur for solar PV and wind power when their production is so strong that market prices are influenced. The corrective amount has a threshold: it cannot become lower than a certain value. Below that value, risks are for the account of the power producers. Subsidies in SDE++ are granted for periods of 12 or 15 years. A different base rate has been set for each technology. The base rate is the cost price for the production of renewable energy or the cost price of the reduction of CO_2 emissions. This base rate is the maximum subsidy rate for which one can apply. By applying for a lower subsidy rate, one has a better chance of receiving a subsidy, as the total annual subsidy budget is limited. An application amount has to be the same as or lower as the base rate.

Source: https://english.rvo.nl/subsidies-financiering/sde (sourced May 2025)

support measures for solar PV and wind energy. There are options that act upon the calculation methods in SDE++ (options 1 to 4) and options that require an adjustment in the PV design or electricity consumption (options 5 to 8).

Option 1: This option entails making a projection for the number of hours with negative electricity price over the subsidy period and converting this to full-load hours. With this option, new numbers of full-load hours are determined for the entire SDE++ subsidy period of 15 years, in which a reduction has been applied for the expected number of hours with negative prices. However, since electricity prices are affected by a variety of developments on both the supply and the demand side of the electricity system, not only in the Netherlands but also abroad, accurately predicting a single number of hours with negative prices in the future is impossible. Underestimation of the real number of hours with negative prices is a considerable risk for the operator, while overestimation is a risk for the subsidy provider. This option would only apply to new SDE++ applications.

Option 2: A graduated scale for full-load hours for determining the base rate (see text box). One way to deal with the uncertainty surrounding the ex-ante estimation of future parameter values is to determine a series of base rates by working with a scale in full-load hours. In this case, the uncertain future is translated into a series of base rates based on a bandwidth of possible full-load hours. At the end of each calendar year, given the realized number of hours with negative prices, the corresponding base rate is selected for the annual ex-post settlement. This option would only apply to new SDE++ applications. Assuming that the bandwidth of possible full-load hours is adequate, this option would offer full compensation to market participants and thus entirely eliminate the risk of an increasing number of hours with negative electricity prices for business cases of solar PV and wind.

Option 3: A correction to the corrective amount (see text box) to compensate for the missed production hours. The corrective amount must be a reflection of the market price. There is already a correction for the profile effect (and up to and including 2024 also for the imbalance effect), but on top of that there could be a correction for the missed subsidy revenues due to the realized number of hours with negative prices. This option prevents the need for ex-ante estimates of the number of hours with negative prices in the future and is therefore easier to operationalize than option 2. This option could apply to both existing SDE++ decisions and new SDE++ applications. This would offer full compensation to market participants and thus entirely eliminate the risk of an increasing number of hours with negative electricity prices for business cases of solar PV and wind.

Option 4: In this variant, the subsidy period is extended (banking: forward banking means that unused but eligible annual production may be caught up in later years). The main advantage is that this ex-post approach prevents ex-ante estimates of the number of hours with negative prices. As with option 3, this option is therefore easier to operationalize than option 2. The application of forward banking is also in line with practice. A potential disadvantage is that once multiple years of banking are necessary, this would mean an extension of the subsidy term by multiple years. This creates longer-term future obligations on the state budget. Part of the subsidy income from the beginning of the subsidy period is then shifted to the end of the period, which may lead to liquidity problems for existing projects. In addition, the net present value of subsidy revenues decreases due to the shift of subsidy towards the end of the period, lowering the SDE++ subsidy. Hence, this option concerns not only a shift of income ('liquidity problem'), but also means lower project income. At the same time, a longer banking or subsidy period provides additional investment security. This means that the risk of an increasing number of hours with negative prices is shared by market parties and the government. That this option requires less government budget than options 2 and 3. This option could apply to both existing SDE++ decisions and new SDE++ applications. In Germany, this option has already been implemented in the renewable energy law (EEG), see the text box.

Extended support duration in Germany

Option 4 as discussed in the SDE++ advice to the Dutch Ministry of KGG has been selected in Germany for financial support for renewable energy generators under the German renewable energy law (EEG). To compensate renewable energy generators for the foregone support payments in quarter hours with negative prices, the support duration is extended by the number of quarter hours with negative prices (rounded up to full calendar days) that occurred over the entire support duration (20 years). For PV plants, the compensation does not simply extend the support duration by the number of quarter hours with negative prices, but considers the varying amount of full-load (quarter) hours of PV plants in Germany across different months of the year. To do so, the total number of quarter hours with negative prices over the entire support duration is first multiplied by a factor of 0.5. This factor considers the fact that PV plants typically do not produce electricity with their full peak power, but only with about 50% of their installed capacity (on average in quarter hours with negative prices). The result can be considered as a time budget of full-load quarter hours. At the end of the support period of 20 years, the support duration is extended until this time budget is exhausted. For each month of the year, the number of required full-load quarter hours is different, ranging from 73 in December to 508 for June. For instance, if there are 2000 quarter hours with negative prices over the entire support period of a PV plant, this is equivalent to a time budget of 1000 full-load quarter hours. If the support period ends at the end of the calendar year, the support duration is extended until the end of the calendar month in which this time budget is exhausted after deducting the respective number of full-load quarter hours in each month – in this example, until the end of April. If the regular support period ends at the end of May instead, the time budget is already exhausted after two months with a high number of full-load quarter hours, i.e. by the end of July.

While accounting for the heterogeneous generation of PV plants over the year, this way of compensating producers for foregone support in quarter hours with negative prices still exposes renewable energy generators to significant liquidity risks, as the compensation payments only accrue after the end of the support duration (i.e. up to 20 years after the foregone payments).

Option 5: A grid connection of less than 50% of the peak power. The lower the connected power, the flatter the delivered profile. At the moment, a grid connection of 50% is prescribed in SDE++. By making this lower, a larger part of the delivered electricity will be outside the peak and therefore also outside the hours with negative prices. This option would only apply to new SDE++ applications.

Option 6: Vertically placed two-sided panels facing east and west. Due to the orientation to the east and west, the PV panels deliver the peak power in the morning, at the end of the afternoon, or the beginning of the evening. A favourable aspect of this variant is that there is less yield in the afternoon. Due to the more favourable generation profile, the profile effect with this variant is less strong than for south-oriented PV. This option would only apply to new SDE++ applications.

Option 7: Vertically placed one-sided panels on building facades. This is the same variant as option 6 above, but with monofacial panels. In this case, the PV panels are mounted on a facade, preferably facing east and/or a facade facing west. This option would only apply to new SDE++ applications.

Option 8: PV system design based on own consumption. There may be processes in buildings that can temporarily consume extra electricity at times when there is electricity surplus. Measures that can be implemented without additional investment can result in extra consumption, for example, by charging electric cars, using climate control when there is a lot of sun (i.e. storing thermal energy in the building), and using existing electrical processes, in particular (product) cooling. More expensive measures include, for example, a battery for day/night storage and a direct line to a large consumer. This option could apply to both existing SDE++ decisions and to new SDE++ applications.

In the Netherlands, the Minister of KGG announced in June 2025 that the government decided not to compensate solar PV projects for the loss of full load hours, and thereby subsidy income, due to the increasing number of hours with negative day-ahead electricity prices. Main reason is that the available budget for the SDE++ is limited and market parties are deemed to limit the impact of negative prices on their business case by steering their own consumption, steering on the orientation of the solar panels, the placement of batteries, and concluding other contract forms or installing a direct electricity line between producer and supplier or customer. According to the government, this also ensures that the favourable effects of negative prices on generation dispatch of wind and solar remain in place. The government acknowledges that for some projects the current market situation, with an increasing number of hours with a negative electricity price, is burdensome and may also affect the continuity of projects. The government wants to implement the instrument of two-sided contracts for difference (expected for 2027) for new solar PV and onshore wind projects, which provides more opportunities to appropriately support the business case of these projects. ▫

REFERENCES

- *Statline, CBS, Renewable electricity; production and capacity, March 10, 2025, https://opendata.cbs.nl/statline/#/CBS/nl/dataset/82610NED/table?ts=1748360776788*
- *Solar PV Monitor 2024 from RVO, October 2024, https://www.rijksoverheid.nl/documenten/rapporten/2024/10/22/monitor-zon-pv-2024*
- *PBL, Final advice SCE 2025, December 2024, https://www.pbl.nl/publicaties/subsidieregeling-cooperatieve-energieopwekking-eindadvies-2025*
- *PBL, Eindadvies SDE++ 2025, February 2025, https://www.pbl.nl/publicaties/eindadvies-basisbedragen-sde-2025*
- *Letter 'Update SDE++: results 2024 and opening 2025' from Sophie Hermans, Minister of Climate and Green Growth, to the President of the House of Representatives, DGKE-DSE/98420399, 6 June 2025, https://www.tweedekamer.nl/kamerstukken/brieven_regering/detail?id=2025Z11605&did=2025D26667)*

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