D2.1-NL, December 2019

Auctions for the support of renewable energy in the Netherlands

Results and Lessons Learnt

AURES II has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 817619

D2.1-NL, December 2019, Auctions for the support of renewable energy in the Netherlands

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Submission date: M14
Project start date: 01 November 2018
Work Package: WP2
Work Package leader: REKK

Dissemination level: PU (Public)

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1 Introduction

This report serves to restate and update the findings of an AURES report published in March 2016 (Noothout & Winkel, 2016) about the Dutch support scheme for renewable energy.[1] While the fundamental design of the "*Stimulering Duurzame Energie*" (SDE+) remains unchanged it is nearing the end of its lifetime and will be replaced by SDE++ in 2020. Hence, it is now possible to assess eight further auction rounds and many more projects that have been realized, which overall warrants an updated evaluation and report.

The Netherlands was the first European country to introduce a large-scale technology neutral auction scheme with the SDE+ in 2011. This Dutch model has been successful in auctioning support for around 25,6GW of newly (to-be) installed RES capacity.[2]

The objective of the report is to provide an overview of the Dutch renewable energy support scheme SDE+ and to evaluate it based on the data available.[3] The key focus is on the auction design of the SDE+ and the effectiveness of the scheme in facilitating the installation and generation of additional renewable energy sources. SDE+ is open for both renewable electricity and heat generation. The focus of the report will be on electricity. The remainder of the report is structured as follows:

- Chapter 2 provides a brief overview of the Dutch electricity sector
- Chapter 3 outlines key features and design elements of SDE+
- Chapter 4 updates the earlier evaluation in the light of the most recent auctions
- Chapter 5 provides some details, as far as known at the time of writing, about the upcoming SDE++
- Chapter 6 concludes the report

[1] The original report is available at: http://auresproject.eu/sites/aures.eu/files/media/countryreports/pdf_netherlands.pdf

[2] Own calculation based on Rijksdienst voor Ondernemend Nederland (RVO) data: https://www.rvo.nl/subsidies-regelingen/stimulering-duurzame-energieproductie/feiten-en-cijfers/feiten-en-cijfers-sde-algemeen.

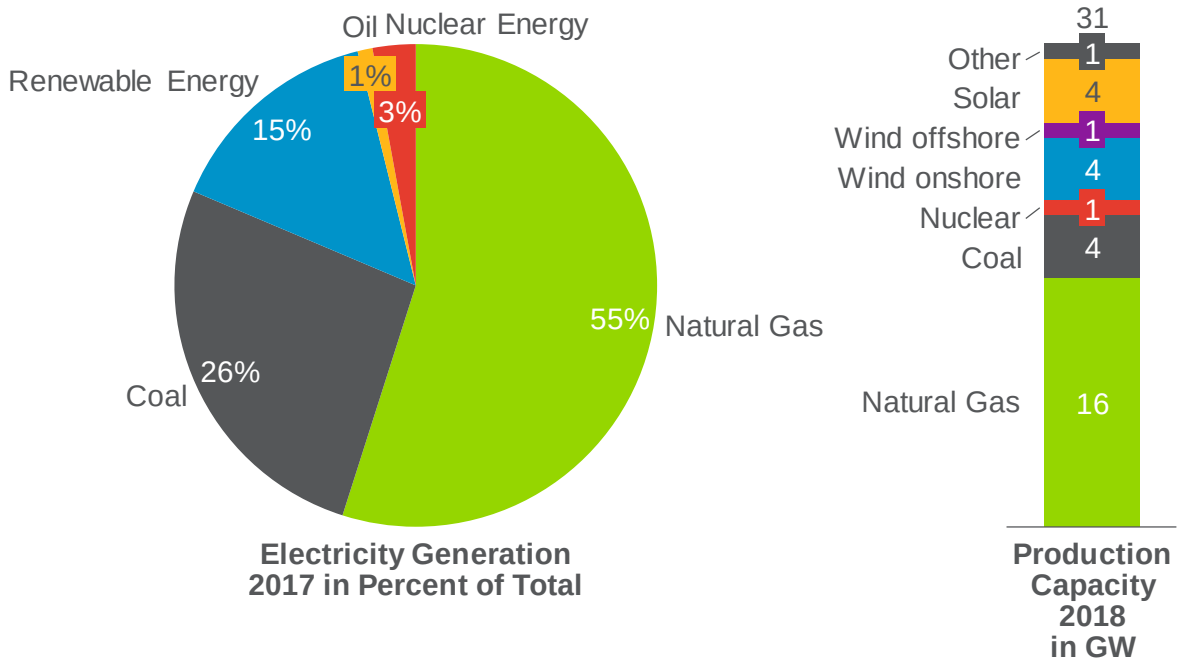
[3] All data used in this report is publicly available at the RVO website. Main source was RVO's facts and figure webpage, where they publish an Excel file with all supported projects and the auction brochures for each round.

2 Overview of the Dutch electricity sector

The generation mix in the Netherlands has changed only gradually over the past years with fossil-based fuels still producing over three quarters of the country's electricity needs (Eurostat, 2019). 55% of the electricity generation of 117GWh in 2017 stems from (natural) gas, around 26% from coal and around 15% from renewable energy sources. This is illustrated on the left-hand side of Figure 1. The right-hand side provides details on the installed electricity generation capacity of the Netherlands. Of a total 31GW, 16GW are natural gas plants, 4GW hard coal plants, 1GW of nuclear capacity and around 10GW renewable energy sources. The latter breaks down in 4GW of solar PV, 4GW of onshore wind installations and 1GW of offshore wind capacity. The remainder is mostly biomass. The Dutch total generation capacity has been increasing, due to the additional renewable generation.

Natural gas electricity generation capacity has been slowly replaced by coal and renewable electricity generation capacity over the last ten years (IEA, 2019)The consumption of renewable energy in gross final energy consumption has grown from 6.6% in 2017 to 7.4.% in 2018 (Statistics Netherlands, 2019). The share of renewable electricity generation was 15% in 2018 (Statistics Netherlands, 2019). Although the share of renewable energy has been growing steadily over the past years, the Netherlands will most likely not reach its renewables target of 14% in gross final energy consumption and 37% of renewable electricity generation by 2020. The Netherlands is part of the Central Western European (CWE) electricity market region and well connected with its neighbouring countries.

Figure 1 Dutch Electricity Production and Generation Capacity



Source: Navigant based on Eurostat & Tennet, 2019

The SDE+, which has replaced the SDE in 2011, is the main support scheme in the Netherlands to stimulate the deployment of renewable energy. There are additional instruments such as the Sustainable energy investment subsidy scheme (ISDE) and the Energy Investment Allowance (EIA). ISDE provides grants for the installation of solar boilers, heat pumps, biomass boilers or pellet stoves in residential and commercial buildings. The EIA mostly supports energy efficiency measures for companies through tax credits. Both schemes are much smaller than the SDE+. Since 2014, projects which apply for SDE+ are not eligible for the Energy Investment Allowance anymore (Netherlands Enterprise Agency, 2014).

3 Characteristics and design elements of SDE+

3.1 Main characteristics

In this section the goals and key characteristics of SDE+ are discussed.

The goal of the SDE+ is to increase RES generation at the lowest possible cost. To this end it was introduced as the first technology neutral subsidy scheme in Europe and is open for renewable electricity, renewable gas and renewable heat or a combination thereof. Eligible technologies are biomass, geothermal, hydro, solar photovoltaics, solar thermal, and onshore wind energy, which all compete under a single budget. Support is auctioned until all budget is used up in a multiple-item sealed-bid auction. The budget increased from €1.7 billion in 2011 to €12 billion in 2017 and 2018. This strategy, of starting with low volumes, is also reflected in the upcoming SDE++ in 2020, which is expected to start with a single round on a smaller budget. Offshore wind energy is auctioned under a separate budget.

3.1.1 Auction design

The auction design of the SDE+ has changed several times since it first auction in 2011, with only one round, 5 phases and a budget of €1.5 billion. Since then the number of phases varied between 3 and 9 and the budget was increased significantly. Since 2016 the SDE+ opens in two rounds each year, one in spring and one in autumn, each consisting of three phases with ascending ceiling prices (ascending clock auction). Each phase is open for one week and has its own technology specific and phase specific ceiling prices that increases each phase. The budget is auctioned on a first-come first served basis, meaning that the auction is capped by budget and not by capacity (IEA, 2018). On the day the budget is exhausted, all applicants from that day are ranked based on their bids and the lowest are accepted first. If there are multiple applications at the same price, a lottery will take place to decide which projects are awarded.

Bidders compete against each other, across all technologies, on price per kWh of produced energy. Bids are bound by the technology specific ceiling price and the phase specific ceiling price:

- Technology specific ceiling prices or base amounts represent the maximum bidding price per technology and reflect the cost price for energy production for a reference situation. In the auction the bid price cannot exceed the base amount. Depending on the combination between the technology and the phase specific ceiling price, project developers can bid for the technology specific ceiling price or are bound by the phase specific ceiling price (see below).
- Phase specific ceiling prices or technology neutral ceiling prices represent the maximum bid price per phase. In every subsequent phase the ceiling price is increased. Phase specific ceiling prices only have a restrictive effect when technology specific ceiling prices are higher.

How bids are influenced by these ceiling prices is illustrated in Table 1. The 2019 spring round consisted of three phases, with a ceiling prices of 0.09€/kWh in phase 1, 0.11€/kWh in phase 2 and 0.13€/kWh in phase 3. The table also shows the technology specific ceiling price in the 2019 spring round for two Solar PV technologies: "Field systems ≥ 15kWp and < 1MWp" (max. base amount of 0.101 €/kWh) and "Building-integrated systems ≥ 1MWp" (max. base amount of 0.095 €/kWh). For both technologies the phase specific ceiling price of 0.09€/kWh determines the maximum bid price in phase 1. In phase 2 project developers can choose to maximise their subsidy and bid for the respective technology specific ceiling price or go for a lower bid. The latter can be considered when project developers expect that the budget will be depleted in this phase. In phase 3 the maximum bid price is determined by the technology specific ceiling price.

Bids below the technology specific ceiling price are referred to as the "free category". The free category was especially relevant in the early years of SDE+, when more expensive technologies were only able to participate in the early phases through the free category, as they were not provided with their own category in early phases. This way, the free category provided developers with the opportunity to access the SDE+ sooner and thus increase their chance to receive support (Gephart, et al., 2016).

Each year, the eligible technology categories and corresponding ceiling prices are recalibrated. The updated

list of technologies, subcategories and ceiling prices are published shortly before each auctioning round starts. For example, the spring 2019 auction saw the discontinuation of the co-fermentation subcategory within the biomass category. The annual budget is published at the end of the preceding year.

Table 1 Ceiling Prices per Phase for selected Solar PV Technologies and the free category in Spring 2019 (Source: Netherlands Enterprise Agency, 2019)

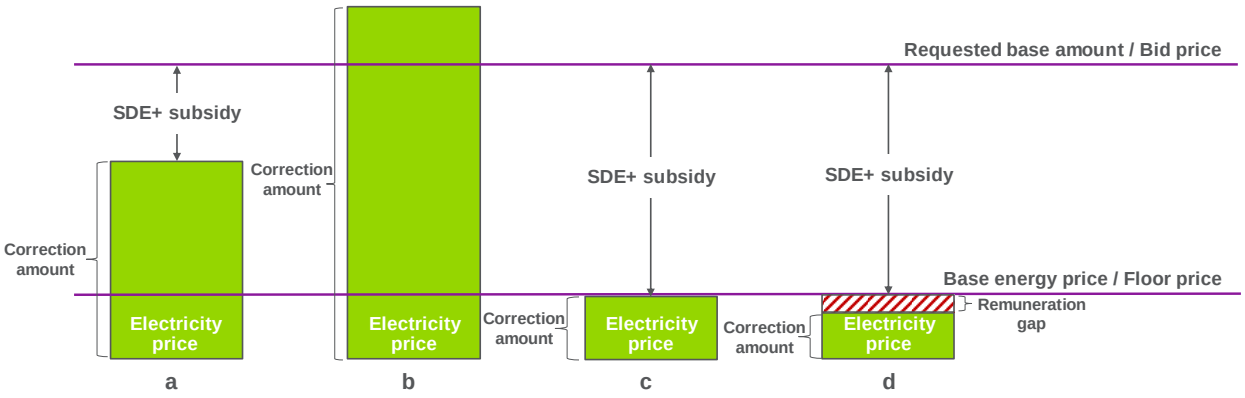
Solar PV	Phase I From 9am 12 March	Phase II From 5pm 18 March	Phase III From 5pm 25 March to 5 pm 4 April	Base Energy Price (grid delivery)	Provisional Correction Amount 2019 (grid deliver)	Maximum Full Load Hours Per Annum
Unit	Maximum base amount / phase amount / technology specific ceiling price (€/kWh)			(€/kWh)	(€/kWh)	Hours
≥ 15kWp and < 1MWp	0.090	0.101	0.101	0.025	0.041	950
Building-integrated systems ≥ 1MWp	0.090	0.095	0.095	0.025	0.041	950
Free category / Technology neutral ceiling price	0.090	0.110	0.130	-	-	-

3.1.2 Feed-in premium design

Projects that have successfully passed the auction are awarded support in form of a slideing feed-in premium. The support level of a project is calculated on a yearly basis by the difference between the bid price and the correction amount. The correction amount is calculated annually based on actual market prices and is the average price of energy per category. The base energy price is the lower bound of the correction amount. This setup makes the SDE+ contribution dependent on the energy-price developments. If energy prices rise, then the SDE+ contribution shrinks, if prices fall it grows up to its maximum. Figure 2 illustrates support payments under four different market scenarios. In scenario **a**, the energy prices were higher than their projected value, hence the correction amount is positive. The height of the SDE+ subsidy is then reduced to the difference to the requested base amount or bid price. In scenario **b**, the energy prices were much higher than projected, and hence the correction amount is large enough that no support is paid at all. Any additional market revenue is kept by the producer. In scenario **c** the correction amount, i.e. the actual energy prices are equal to the base energy price, therefore the maximum SDE+ subsidy is paid out. In scenario **d**, the market value falls below the base energy price, the resulting correction lower is also lower than the base energy price. While full SDE+ subsidy is paid, the resulting loss in remuneration due to the lower market prices is for the producer to carry. This means that there is no guaranteed price floor for projects, increasing the revenue risk for developers in case of declining prices. From the government's perspective, this setup has the effect that maximum support payments are capped and that support payments usually stay below budget. If prices rise on average, less support than budgeted needs to be paid. Only if prices were to drop to/below the floor price permanently, the full amount of the budgeted support would need to be paid.

No subsidy is paid for feeding in renewable electricity into the grid if the electricity price is negative for six consecutive hours, with some exemptions in place for small projects which were installed before 2015.

Figure 2 Illustrative payments of subsides under the SDE+



Source: Navigant

Support in SDE+ is only received for a fixed amount of full load hours a year. This maximum is again technology specific, e. g. an all-purpose fermentation CHP plant which won support in spring 2019 can only receive subsidies for 7,622 full load hours and a solar PV plant between 15kWp and 1MWp capacity for 950 full load hours per year (Netherlands Enterprise Agency, 2019). Full load hours for offshore wind are project based on and vary according to net P-50 values. To provide some flexibility to this framework, banking of production was introduced, i.e. using unused subsidisable production in subsequent years. The forward banking of underproduction was available from the start in 2012 while backward banking of overproduction was only introduced in 2015. Forward banking allows installations to transfer unused support in case of lower annual production than anticipated to the following years (underproduction), with no limit on the transferrable amount. Backward banking in the case of overproduction is the reverse case and allows projects to transfer up to 25% of subsidisable generation to the following year. Offshore wind, co-gasifications and biomass installations have different banking rules.

Since 2015, offshore wind auctions were done under a separate budget. The Dutch government initially agreed to a roadmap ensuring a total installed capacity of 4.5GW until 2023 across five different development zones. This was updated in a new roadmap in which an additional 4GW is to be auctioned between 2024 – 2030. Sites are pre-developed, and cost of grid connection provided by the transmission system operator. So far there have been five different auctions with a sixth set for Q4 2019. Since 2017, offshore auctions allow for zero subsidy bids and are evaluated on a) the knowledge and experience of the parties involved b) the quality of the design for the wind farm c) the capacity of the wind farm d) the social costs e) the quality of the inventory and analysis of the risks f) the quality of measures to ensure cost efficiency.

3.1.3 Other main characteristics

Table 1 provides a structured overview of the main characteristics of SDE+. Table 3 provides an overview of the main auction design elements.

Table 2 Main characteristics

Characteristics	Description
Goals	The SDE+ aims at realizing RES generation at the lowest possible cost and is the main tool to achieve the Dutch 2020 renewable electricity target.
Characteristics of the national electricity market	The Netherlands has a binding EU renewable Energy (RE) target of 14% in 2020, which it is projected to miss. The RE share in gross final energy consumption in 2018 was 7.4%.[4] To the common EU target of 32% RE across all member states by 2030, the Netherlands is planning to contribute with a national share between of 27 to 35% of renewable energy.
Name of auction scheme	The current support scheme Stimulation of Sustainable Energy Production (Stimulering Duurzame Energie, SDE+) will be replaced by the Sustainable Energy Transition Incentive Scheme (Stimuleringsregeling Duurzame Energietransitie SDE++) in 2020. In this new scheme the focus will be on reduction of CO2 (instead of generation of renewable energy) and it will also allow CO2 reducing industrial technologies to participate.
Contractual counterparty	The Netherlands Enterprise Agency (Rijksdienst voor Ondernemend Nederland, RvO) was founded to encourage entrepreneurs in sustainable, agrarian, innovative and international business. It is the executive agency of the Dutch Ministry of Economic Affairs.
Main features	The SDE+ auctions a sliding feed-in-premium which is determined through a technology neutral multi-round auction process.
Technology focus and differentiation (eligible technologies)	Renewable energy sources for electricity, renewable energy sources for heating and cooling as well as biogas are eligible for support under the SDE+. Although the design of the instrument differentiates between technology categories, the SDE+ scheme is a technology-neutral scheme. Technologies compete under a single budget. The exception is offshore wind energy, which has been tendered under a separate budget since 2014.[5]
Lead time before auction	The budget and number of rounds per year are published the year before, the exact auction details, such as ceiling prices are published several weeks before the opening. Usually only minor adjustments to the auction design are made, such as variations in the ceiling prices. There is considerable uncertainty around the auctions in 2020 as very little information about SDE++ is official yet. Offshore wind energy follows a fixed roadmap until 2024, with the follow-up roadmap for 2024-2030 already under development. Currently, there exists a planned and intended tender schedule until 2025.
Min./max. size of project	The number of projects is not restricted. However, most technologies are subject to a minimum project size which can be found in the auction brochure. For example, in 2019 solar PV installations needed to have at least 15kWp and be connected to a large-scale grid to be eligible to apply. The exception is onshore wind, for which no minimum project size is indicated. (Netherlands Enterprise Agency, 2019)

[4] Statistics Netherlands https://www.cbs.nl/en-gb/news/2019/22/share-of-renewable-energy-up-to-7-4-percent
[5] For additional details on offshore wind auction please see https://english.rvo.nl/subsidies-programmes/offshore-wind-energy

What is auctioned?	The scheme auctions a predetermined support budget. Support payments are made in form of a sliding premium.
Budgetary expenditures per auction and per year	Both rounds in 2019 had a budget of €5 billion. In 2017 and 2018 the spring and the autumn round had a budget of €6 billion each. Auctioned budget is illustrated in **Figure 6.** Annual support paid varies over time and market conditions but is not made public. **Figure 4** provides an overview of the estimated budget expenditure for SDE+ support each year.
Frequency of auctions	Since 2016 there have been two auction rounds a year, one in spring and one in fall. The number of phases per auction before 2017 varied over the year, currently each round has three phases. Phases only differ in the applicable ceiling prices, which are all communicated before the start of the auction and the budget still available.
Volume of the tender	The SDE+ has no fixed capacity volume per round. The limit is set via the budget available in each round for support. **Figure 6** in Section 4 provides an overview of the budgetary evolution over the lifetime of SDE+.
Grid connection/access related costs	The costs for the connection between the installation and the closest grid connection point are borne by the project developer, costs for grid enforcements by the DSO/TSO. Costs for land lease, permitting, etc. are all paid by the project developer.

3.2 Auction design elements

Table 3 Design Elements

Design elements	Description
Auction format	The Dutch SDE+ scheme is a multiple-item auction where bids/projects are awarded up to the auctioned budget. The auction is technology neutral, however bound to a list of pre-selected technologies for which individual ceiling prices are determined. Since 2017 each auction had three phases, with the ceiling price rising continuously with each phase. Ceiling prices are technology specific. A technology neutral ceiling price for the auction exists.
Eligible technologies and participation technologies?	Eligible technologies are biomass, hydro, solar photovoltaics, solar thermal, geothermal and onshore wind for both electricity and heat generation. Offshore wind hast its own auction scheme.
Auction procedure	Dynamic
Pre-qualification requirements	SDE+: • Environmental permit, mining permit if required, need to be handed in with the bid. • Feasibility study for installation above 500kWp (see below) • Energy yield calculations for Wind onshore and Solar PV installations • Geological survey for geothermal energy • Permission of the owner, if the bidder does not own the land. • Financial guarantee is only required for projects above €400 million (see below at penalties for further information). Offshore Wind: • Project Plan • Wind report • Operational calculation • Annual accounts • Financing plan

	• Table of wind turbine details and locations • Bank guarantee if bid is successful. Feasibility Study: Since 2014 it is required to submit a feasibility study with the application for projects that are larger than 500kWp or 50Nm³/h. A feasibility study is also required when the capacity of multiple solar-PV projects of one applicant exceeds 500kWp. The feasibility study should contain the following elements: • Exploitation statement with: o A specification of the investment costs per (main) component of the production installation o A cost-benefit analysis of the installation o A profit & loss statement with expected returns on investment • Statement of the level of equity and financing: o Provide documents to substantiate equity (e.g. annual statement); o For projects with less than 20% equity: a letter of intent from a financing party stating capacity and willingness to finance the project; o Calculations and projections of the expected production from wind (based on the wind viewer), hydro, biomass and waste sources (only these sources). • For biogas projects: a statement from the responsible DSO of the costs for feeding into the gas network; • For renewable heat projects: an assessment of the heat demand (prove of sufficient demand/customers for the heat from the installations).
Auction volume	Auctions have a fixed budget ceiling. The volume in terms of MW varies accordingly.
Pricing rule	The SDE+ is a pay-as-bid auction, whereby the winning bidder receives the price of its bid.
Award procedure	The price per kWh is the single award criteria.
Price limits	Yes, technology specific ceiling prices, called base amount.
Support period	8 (boilers), 12 (biogas) or 15 (solar, onshore and offshore wind) years. While offshore wind projects only receive support for 15 years their operational permit is valid for 30 years.
Favourable treatment of specific actors	Not explicitly. However, technologies often have different ceiling prices depending on the size of the installation which can lead to a possibly higher support for smaller projects. Example: • In phase 2 installations between ≥15kWp and < 1MW had a ceiling price of 10.1ct/kWh. Building integrated systems ≥1MWp 9.5ct/kWh and non-building integrated systems ≥1MWp 9.3ct/kWh. • For wind on land the ceiling prices differ according to windspeeds. For this, five different wind speed categories have been defined and a wind map of Dutch municipalities developed.
Realisation time limit	There are 1.5 – 4 years for solar installations (depending on size), 4 years for onshore wind and biomass and 5 years for offshore wind.

Penalties	Since 2012, non-financial penalties are in place for the non-realisation of projects within the required period. If projects are not operational within the realisation period, the project loses its support right and is excluded from SDE+ for a period of 3 years. However, in some cases it was possible for geothermal developers to work around this exemption by "redefining" the project (e.g. by changing the capacity) and apply again. These loopholes were largely closed. For projects that claim >€400 million (over their lifetime) in the case of non-realization a fine must be paid of max. 2% of the budget claim of that project. The bank statement (required for these projects) has to guarantee payment of this 2%. Like the other projects, these projects are exempted from SDE+ for 3 years. No projects are known to have claimed >€400 million in the past years. No information is available why such high limit was chosen. Over the lifetime of SDE+ several measures have been introduced to ensure high realisation rats and unnecessary budget claims:[6]: • Since 2014: a feasibility study is an important qualification requirement (see section on qualification criteria). This is seen as a major contribution to improving the realisation rate; • Project developers of projects that are not realised are excluded from SDE+ for three years, for the same project; • Stricter check on project feasibility and their economic viability on the basis of an assessment of the realisation and a financial plan that are submitted by applicants; • Check of progress after one year by RVO; • For projects with a budget claim >€400 million a bank statement and a realisation contract is required. The contract states that the project has to be realised within the given timeframe.
Way of monitoring progress of realisation	Within 12-18 months of having won the subsidy, copies of the job assignments that outline the components of production installation and the construction contracts must be submitted to RVO. [7] Small PV installation with a realization limit of only 18 months are exempt from this rule.
Form of support auctioned	Support is auctioned in form of a sliding feed-in-premium
In case of premium schemes describe the method of reference wholesale price calculation	The premium is based on the base energy price amount as illustrated by the Feed-in premium design Projects that have successfully passed the auction are awarded support in form of a slideing feed-in premium. and **Figure 2,** which represents the electricity price estimation for the year. When the year is over, the real electricity price can be calculated, and the base energy price is then rectified by the correction amount.
Support level adjustments	The technology specific ceiling prices are adjusted from year to year, for each new round. This has now influence on already auctioned support. The correction amount, which is based on the market value of the energy supplied, is calculated annually and determines the height of the exact SDE+ contribution (as illustrated in Figure 2). Support is capped

[6] https://wetten.overheid.nl/BWBR0022735/2012-03-13#Paragraaf7

[7] The brochure for Spring 2018 speaks here of 12 months while the brochure for Spring 2019 speaks of 18 months (Netherlands Enterprise Agency, 2018 and 2019).

	annually at technology specific limit of full load hours. Over- or underproduction can be banked for use in later years, with a limit of 25% transferrable overproduction and no limit of transfer of unused funds due to underproduction.
Transferability of support right	Not without a ministerial permission until the installation is in commission.[8]

[8] See §7 article 61 of the SDE, available at: https://wetten.overheid.nl/BWBR0022735/2012-03-13#Paragraaf7

4 Evaluation of the auction results

To evaluate the effectiveness of SDE+ against its policy goals requires a clear and concise statement of these goals. For SDE+ there are two main goals:

- To encourage the generation of RES at the lowest possible cost,
- to contribute to the Dutch 2020 renewable energy goal of a share of 14% renewable energy in gross final energy consumption (European Commission, 2019).

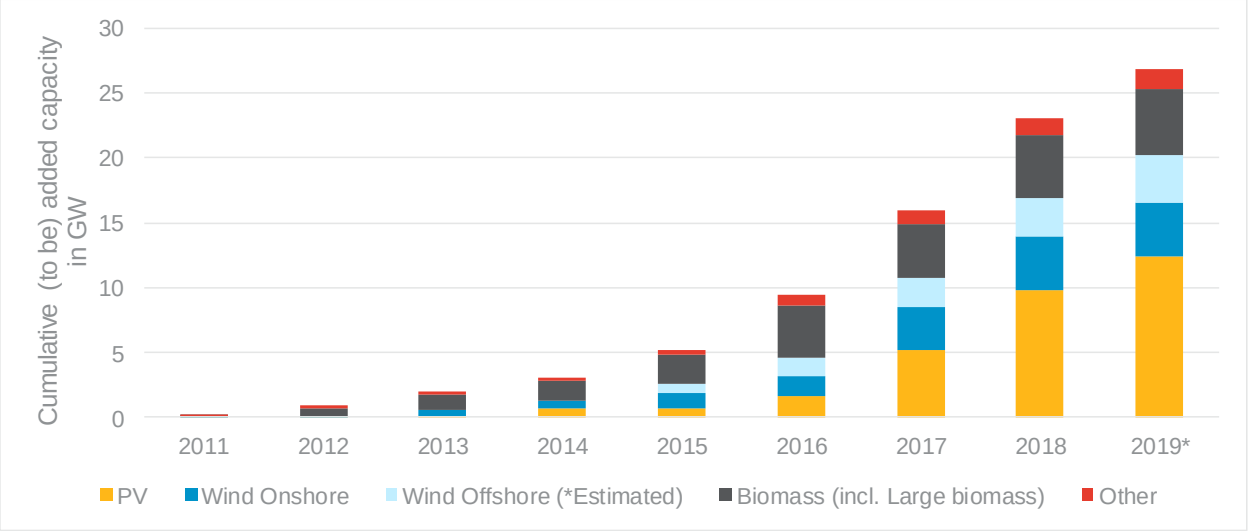
This translates into three questions that need to be answered. First, is the instrument itself effective, secondly was the budget high enough to reach the target, and thirdly was the goal achieved at the lowest possible cost? The data used in the analysis is from RVO's publicly available list of projects under management [9].

4.1 Effectiveness in target achievement

SDE+ is the main tool of the Dutch government to achieve its 2020 renewables targets. From this point of view, SDE+ was "too little too late", as the mismatch between the renewables target and the actual generation show (see chapter 2).

Fehler! Verweisquelle konnte nicht gefunden werden. shows the cumulative capacity that was auctioned each year, including the offshore wind capacity, which is auctioned under a separate budget. By the spring 2019 around 25,6GW of RES capacity is expected to be build and supported through SDE+. It also shows that around half of the supported capacity is solar PV, with 12GW, biomass comes second, with around 5GW capacity, then onshore wind with 4,2GW, offshore wind with 3,7 GW and finally other RES technologies such as waste and geothermal energy with around 1,5GW.

Figure 3 End of Year Cumulative Auctioned Capacity through SDE+ (incl. Offshore Wind)



Source: Navigant based on RVO data

The current Dutch generation capacity of around 31GW generation capacity, with 21GW being fossil based, and 9GW already being renewable, will permanently be changed with the auctioned 25,6GW, which will eventually replace large parts of the fossil-based capacity. However, they will not be deployed fast enough to

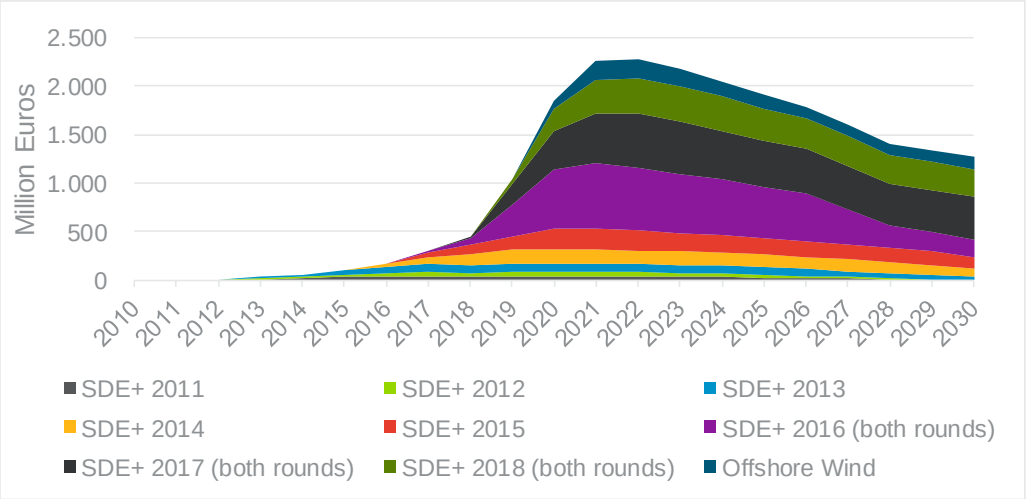
[9] RVO publishes an Excel file with all projects under management within SDE+ which is available here: https://www.rvo.nl/subsidies-regelingen/stimulering-duurzame-energieproductie/feiten-en-cijfers/feiten-en-cijfers-sde-algemeen The data used for the analysis in this report was from August 2019.

meet the 2020 targets. This has two reasons: First realization rates at the beginning of SDE+ were low and second the budget was increased too late, so that a significant part of new installations will only become operational around or after 2020.

Up until 2014 almost 50% of the auctioned volume was not realised due to delays (Rijksdienst voor Ondernemend Nederland, 2019) or when banks refused loans as subsidies turned out to be not sufficient to support the project. This started to change from 2014 onwards, when measures were implemented to reduce the share of non-realisation. These measures included the submission of a feasibility study and stricter permitting rules. (Netherlands Enterprise Agency, 2014) This resulted so far in an increase realization rates, which are for 2012 and 2013 close to 50%. As of November 2019, only around 10% of project capacity in 2015 was not realized. Final assessment on the effectiveness of the introduced measures can only be made once all realization periods are over, which is currently not yet the case (Rijksdienst voor Ondernemend Nederland, 2019).

Fehler! Verweisquelle konnte nicht gefunden werden. shows the projected support costs for each year of SDE+, based on the estimated payment of SDE+-subsidies to project developers. The years with more than one round were aggregated. The figure shows that running expenses were below €500 million per year up to 2018. From 2018 onwards the annual expenses increased significantly, which coincides with the first installations of 2016 (when the SDE+ budget increased significantly) starting to generate energy. The peak support period is expected to be in the years 2021 and 2022 when all the installations from the budget heavy years 2016 – 2019 will start their production. What is underlying this projection by RVO is the assumption of declining electricity prices in the 2020s.

Figure 4 Projected support costs under SDE+



Source: Navigant based on RVO data.

Awaiting the realization of the most recent rounds from 2017 onwards one can say that SDE+ effectiveness in the early years was mixed at best. High rates of non-realization and withdrawn financial support delayed the implementation of new capacity. This changed with the mandatory feasibility study from 2014 onwards, which led to increasing realization rates and a declining number of projects where support was withdrawn. From 2015 onwards SDE+ succeeded in auctioning support for an additional 5GW of renewable capacity each year. Overall, SDE+ succeeded in auctioning support for over 2,6GW of renewable energy capacity, even though 18GW of it still needs to be build.

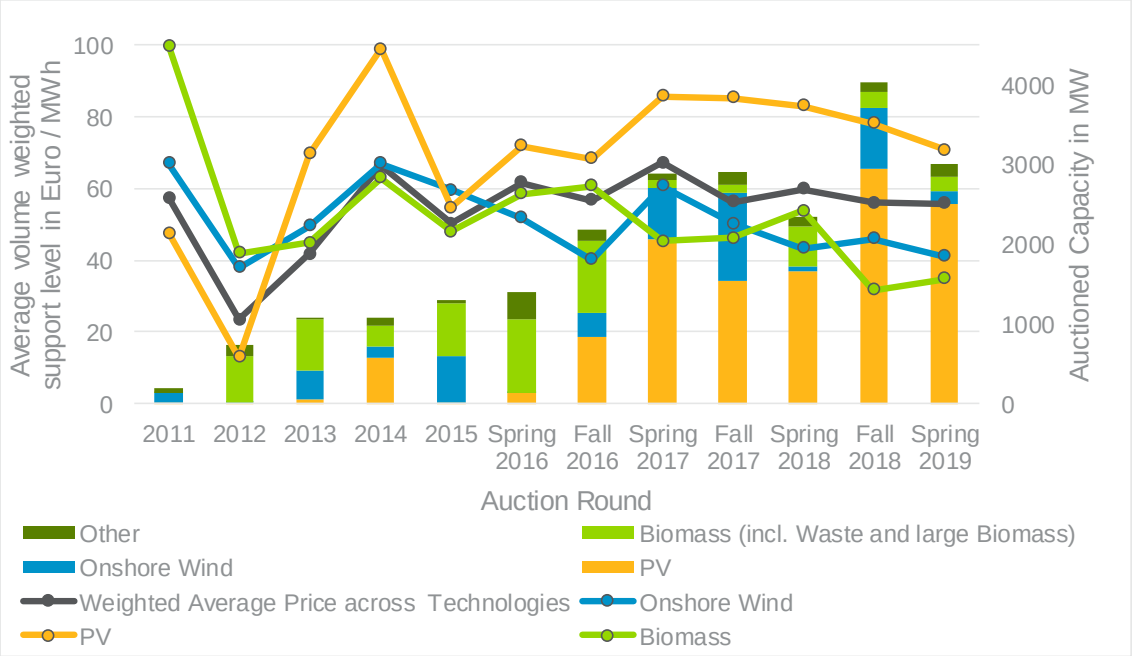
4.2 Cost effectiveness

Over the first couple of years the results of the SDE+ was subject to large price swings. This was caused by both the set-up of the SDE+ (smaller budgets, one round per year with regular budget-updates) and the availability of relatively cheap projects. In years where a lot of relatively cheap projects were available, the budget got depleted in an early phase. Project developers of more expensive projects received this

information through the regular budget updates and could make two choices: go for a lower strike price or wait for another full year. In years were less subsidy was claimed by relative cheaper options, project developers of relative expensive projects could afford to maximise their subsidies. From 2016 onwards, the system was changed by introducing two rounds per year and not providing regular budget updates. Since 2017, overall prices have started to decline slightly, mostly due to reduced ceiling prices.

Projects in SDE+ compete against each other based on bid prices in €/MWh and are selected thereupon. In theory, if a budget is limited, sites abundant and competition assured, an auction should lead to prices close to actual production costs. Factors which influence the level of competition and therefore potentially also bid prices are for example the timing of the bid of different technologies, the availability of projects and information about the remaining budget. The timing of bids is important because if a low-cost technology bids in an early phase and thus uses up lots of budget, other technologies need to bid in the early phase too, in order to receive budget. The regular budget updates provided by RVO allowed developers to time their bid depending on available budget. RVO stopped publishing information on budget used in between phases in 2016.

Figure 5 Maximum SDE+ support level (average per technology) and contracted capacity



Source: Navigant based on RVO data

Figure 5 provides the average support level for biomass, solar PV, onshore wind energy and the technology neutral average price in Euro/MWh across all technologies on the left y-axis as well as contracted volume per technology in MW on the right y-axis. Strike prices are calculated based on RVO data.[10] The bars indicate the capacity which was contracted through the auction in each round. Several things stand out when looking at the figure. Overall, there is a clear upward trend in the procured capacity: the increase in volume corresponds to the increase in auctioned budget (see Figure 6). The low support level for solar PV in 2012 was the result of an early budget depletion, caused by the large amount of relative cheap biomass projects that used up the budget and therefore acted as price-setting technology. Therefore, only the cheaper solar-

[10] RVO publishes capacity of each installation, maximal subsidized fully load hours per year, the duration of the subsidy and the maximal subsidy over this duration. Strike prices are then calculated by dividing the maximal available subsidy by the duration of the subsidy in years to receive the annual subsidy available for each installation. This is subsequently divided by the maximal subsidized full load hours per year to receive an installation specific strike price. Average strike prices for Figure 5 are the volume weighted.

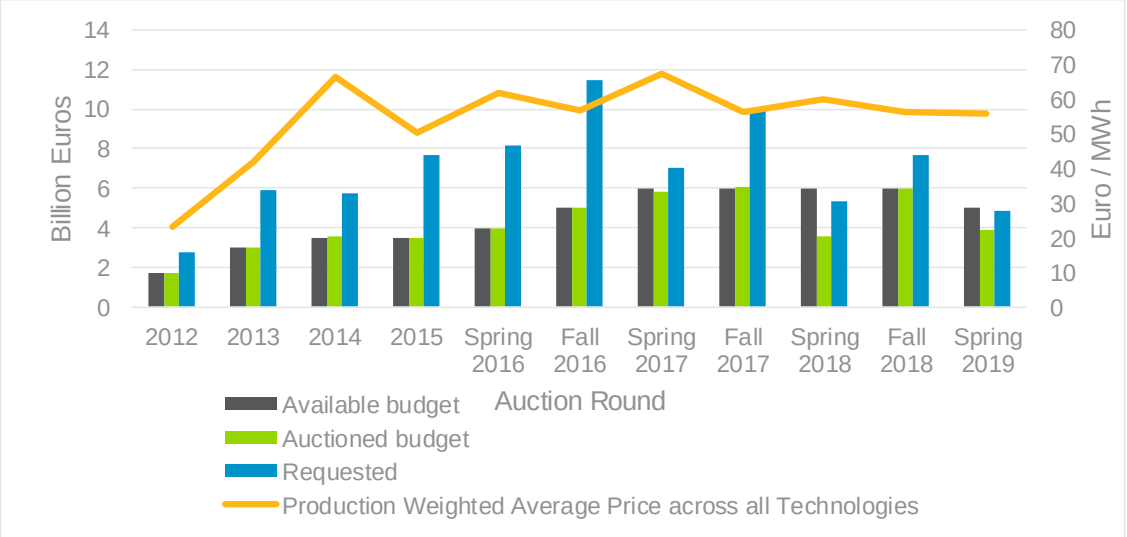
PV projects that could afford to bid in the first phase were awarded at a very low ceiling price.[11] The awarded capacity for solar was only 5MW in 2012. The auctions in spring 2018 and 2019 were undersubscribed in part due to much less wind onshore bids and hence less volume was procured. The reason for the undersubscription is a dry up of the project pipeline for onshore wind projects, which in turn is a result of a decrease in suitable projects, public opposition to new projects, as well as a lack of permits that were given (Wiebes, Resultaten SDE+ voorjaarsronde en toezeggingen AO Energie & Klimaat, 2018).

From one round to the next there were significant changes in the price and the amount of capacity that a technology was able to secure. The most common explanation for this is that different technologies set the clearing price. If a certain technology uses lots of budget in an early phase it forces other technologies to also bid at low prices in the same phase or risk not getting awarded at all. As mentioned above, this happened with biomass and solar in 2012 and it happened again with onshore wind and biomass setting the price for solar PV in 2015. The reverse was true in 2016 when only very little onshore and biomass capacity participated, allowing solar PV developers to wait until a later phase to request high prices close to the ceiling price. In order to reduce this kind of strategic behaviour RVO stopped publishing interim results. Another reason for price variations can also be changes in the ceiling price of a certain technology, especially when technologies bid close to the ceiling price. This happened for all-purpose fermentation CHP biomass plants when ceiling prices were reduced from 87€/MWh to 65€/MWh in spring 2017 (Netherlands Enterprise Agency, 2016 & 2017). Other non-auction design related reasons for changing prices can be the dry up of the project pipeline due to permitting issues and local legislation as happened in the case of onshore wind energy in spring 2018 (Rijksdienst voor Ondernemend Nederland, 2018 and Proka, Hisschemöller, & Loorbach, 2018). Since late 2016, solar PV has been the price setting technology with only small subsequent decreases in support level. Overall, it can be said that there was a slight decrease in support for most technologies from 2017 onwards, which was largely driven by decreasing ceiling prices. Support levels are most often determined by one price-setting technology, which then heavily influences the price of the other technologies, either because they drive down prices for more expensive technologies or because they allow cheaper technologies to bid up to their ceiling price.

Figure 6 depicts the available, requested and auctioned budget for each round as columns on the left y-axis and the average strike price as line on the right y-axis in Euros/MWh. The grey columns indicate the available budget, the blue columns indicate the requested budget and the green columns indicate auctioned budget at each round in billion euros. Requested budget can also be seen as a proxy for competition. In general, it can be said that the higher an auction is oversubscribed the more competition there is for the available budget, which means that the resulting strike prices can be expected to be lower. By implication the reverse holds also true, if the auction is under-subscribed there is less competition for budget, hence higher strike prices can be expected. However, neither of these trends is properly reflected in the SDE+ (See Figure 6). This has two main reasons, first, the price indicated is a technology neutral price and secondly, projects tended to bid at their ceiling prices both when auctions were oversubscribed and when they were undersubscribed. This effect can be seen in the spring auction in 2018, which was significantly undersubscribed requesting just €5,3 billion out of €6 billion available budget. However, prices for both solar and onshore wind continued to drop slightly, while the one for biomass increased (see Figure 5 above). The ceiling price for wind was reduced in all categories from fall 2017 to spring 2018 while those for solar PV remained constant (Netherlands Enterprise Agency, 2017 & 2018). This coincided with a significantly fewer bids for onshore wind installations due to difficulties in the project pipeline as explained above. Only around €3,6 billion of the available €6 billion budget were auctioned. Even though the auction was undersubscribed from the start, the Dutch government rejected over €1 billion in support of installations due to incomplete bids such as lacking permits (Rijksdienst voor Ondernemend Nederland, 2018).

[11] This result was confirmed by the RVO.

Figure 6 Budget evolution and indicative competition in SDE+



Source: Navigant based on RVO data.

More notable are the results achieved in the offshore auctions. Shortly after changes in the auction scheme were made to allow for zero subsidy bids, the Netherlands received their first zero subsidy bids in its Hollandse Kust Zuid tender in 2017. In the 2018 tender all bids were zero-bids and developers distinguished themselves by demonstrating an effective risk mitigation strategy. It is now even expected that future rounds will allow for developers paying for the concession rights, i.e. submit negative bids. This would require a revision of the Offshore Wind Act (Van Steen, Prinsen, & Paberzs, 2019).

Such low bids can be explained through several factors: First and foremost, the Dutch government shifts some of the project risks, such as paying for the grid connection to the transmission grid operator (WindEurope, 2018). The certainty provided by the one-stop-shop principle of awarding concession, permit, and grid connection also helped to reduce costs (Van Steen, Prinsen, & Paberzs, 2019). The long-term auction schedule allows developers to build economies of scale. Conditional bids allow developers to take advantage of winning more than one bid. Guarantees of origin in the Netherlands are provided to each installation, providing them with an additional revenue and making long-term power purchase agreements more attractive, which can be used to mitigate the merchant risk and keep financing costs low (OffshoreWind.biz, 2019). Finally, site conditions are usually excellent, i.e. limited water depths, high wind speeds and close distance to the shore (Van Steen, Prinsen, & Paberzs, 2019).

Over the years auction design of the SDE+ changed significantly when compared to the first auction rounds, which had 5 – 9 phases and only one round. Information about remaining budget led to some strategic behaviour resulting either in unusually low or high results, such as solar PV in 2012 and 2014 respectively. The technology-neutral volume weighted strike price zig-zags after its record high in in 2014, with a slight downward trend from 2017 onwards. In general, it can be said that only small support reductions could be achieved for most technologies, which were mainly driven by the reduction in ceiling prices. The exception is offshore wind, where significant support reduction could be achieved.

5 Outlook: the broadening of SDE+ to SDE++

In 2018 it was decided to replace SDE+ with SDE++ from 2020 onwards, which will include industrial technologies. The idea is to allow an increasing number of industrial electrification technologies into the scheme and change the target from generating renewable energy to reducing carbon emissions.

After an initial draft in December 2018 details were published in a letter to parliament in April 2019 and are currently being consulted upon with stakeholders (Wiebes, Verbreding van de SDE+ naar de SDE++, 2019). SDE++, as it will be called, has as the main goal to "reduce CO2-emissions at the lowest possible costs". SDE++ is the main tool to achieve the of the climate agreement of a minimum reduction of 49% in CO_2 emissions compared 1990 by 2030 (Wiebes, Verbreding van de SDE+ naar de SDE++, 2019). The instrument and auction mechanism will remain more or less unchanged, meaning that technologies to reduce CO_2 emissions in the industrial sector will compete with RES generation technologies in the same scheme under one integral budget. Conversion factors will be used to compare the impact on CO_2-emissions and thus the strike prices for the individual technologies, which will be expressed in €/ton CO_2 avoided. Such a set up would resemble a market premium instead of the currently used sliding feed-in tariff. The Dutch governmental agency PBL was tasked with defining suitable methodologies per technology, e.g. translating renewable electricity into CO_2 savings. A limited number of industrial technologies is currently being assessed for possible inclusion in SDE++ as of 2020, including electric boilers, industrial heat pumps, waste heat, green hydrogen production and carbon capture and storage.

At the time of writing of this report much of the details of SDE++ were still uncertain, most importantly how the baseline emission factors for the eligible technologies are calculated. Nevertheless, several aspects can be noted:

- An integrated auction for both demand and supply side of this scale would be a novum (with the exception of EU-ETS). As SDE++ will function via a price on CO_2 the interplay with the European Emission Trading Scheme (EU-ETS) needs to be kept in mind.
- If companies will compete on €/ton of CO_2 avoided they will need to formulate their bids accordingly. This means that not only electricity prices but also CO_2 prices need to be forecasted, which introduces further uncertainty for all parties involved. To this end, the Netherlands introduced separate carbon floor prices for electricity generation and industrial usage in their national climate agreement (Government of the Netherlands, 2019).
- The calculation of the base amounts and the correction amounts for €/ton of CO_2 will be much more complex than under SDE+, where they only referred to energy production in the form of €/MWh.
- Towards 2030 the SDE++ will focus much more on potential CO_2 savings from industrial processes. This is based on the intention not to subsidize further new RES installations after 2025 (Afspraken voor Elektriciteit, 2019) . The indicative budget of €1 billion for SDE++ in 2030 sees around €500 million for CO_2 reductions in the industry and only around €200 million for electricity generation and €235 million for renewable heat and green gas (Rijksdienst voor Ondernemend Nederland, 2018).
- Electrification options in the industry are creating an additional challenge, as these options will only reduce CO_2 when sufficient renewable electricity is available. In the SDE++ concept an emission factor of 0,183 g/kWh of electricity is being discussed as the 2030 grid emission factor. Depending on the technology and its electricity demand, some electrification options might not result in CO_2-reductions.
- With the move from SDE+ to SDE++, the Netherlands will no longer have a policy instrument to ensure national/European RES target achievement.

6 Conclusion

The SDE+ has been continuously changed and improved over the years and several challenges have been overcome. These include the initial high rates of non-realization of projects until 2014, which were addressed through mandatory feasibility studies and stricter permit requirements. However, the final effectiveness of SDE+ can still not be evaluated, as all years since 2015 still have a significant share of projects to be realized. The strong price fluctuations for solar PV strike prices between the years 2012 – 2015 were reduced through not publishing information about the remaining budget between phases and thus reducing strategic behaviour. Since 2017 strike and ceiling prices started to drop slowly for most technologies due to reduced ceiling prices, which is also reflected in the production weighted average price across all technologies. Dutch offshore wind auctions received record low, i.e. zero support bids.

SDE+ succeeded in auctioning support for over 25,6GW of renewable energy capacity, even though 18GW of it still needs to be build. It did not succeed in achieving significant support reductions, except for the technology-specific offshore wind tenders. Especially in the earlier years it occurred that projects bid at considerably lower costs to be able to receive support at all. More often cheaper technologies bid at higher prices because another, more expensive, technology was setting the price. Overall it can be set, that the ceiling prices were extremely important and relevant for the small price decline in recent years.

he planned overhaul and development of SDE+ towards SDE++ changes it from a renewables support scheme to a CO2 emission reduction support scheme, aiming mainly at reaching national GHG targets rather than renewables targets. The introduction of new industrial technologies and comparison methodology based on Euros per ton of CO_2 avoided poses several challenges such as setting correct base amounts (ceiling prices). To this end SDE++ will start small in 2020 and can be expected to grow and be improved throughout its lifetime as SDE+ has been.

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AURES II is a European research project on auction designs for renewable energy support (RES) in the EU Member States.

The general objective of the project is to promote an effective use and efficient implementation of auctions for RES to improve the performance of electricity from renewable energy sources in Europe.

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AURES II has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 817619