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The Dutch methodological approach for national energy savings and related greenhouse gas emissions reduction for sectors and policies

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ABSTRACT

Energy saving is a key pillar for the path to decarbonization for the European Union (EU) and the rest of the world. As a part of the regulatory framework, EU member states are obliged to report their energy savings and greenhouse gas (GHG)-emissions reduction biannually, up to 2020 separately (as an obligation under the Energy Efficiency Directive and under the Monitoring Mechanism Regulation) and from 2023 onwards in their national energy and climate progress reports (NECPRs). Due to the inherent diversity among member states, there is no universal methodology applicable for the different sectors and policy measures. The Netherlands decided to develop an integrated method for both energy savings and GHG emissions reduction. This combination is a challenging one since not all GHG emissions reduction lead to energy savings and vice versa.

The Netherlands has more than fifty policy measures resulting in final energy savings in four sectors: (I) the built environment, (II) horticulture, (III) mobility and (IV) industry. A sectoral distinction is made for policy measures as well as for cross-sectoral policy measures.

To calculate energy savings, the energy use of a new technology is compared with that of a reference technology. For the reference technology two approaches are used. One is the present situation, the other is the same technology meeting current minimum EU standards (such as Ecodesign). The difference between the new and reference technology is the energy savings as a result of applying the technology (c.p.). Results are aggregated to a (sub)sectoral level in order to avoid double counting of energy savings from interacting policy measures.

In order to calculate the GHG emissions reduction from energy savings, the emission factor is multiplied with the amount of energy produced avoiding the consumption of fossil fuels.

Introduction

Energy saving is a key pillars for the path to decarbonization for countries, including the European Union (EU), to meet the objectives of the Paris Agreement (IEA, 2021). As a part of the regulatory framework, EU member states are obliged to report on their energy savings and GHG emissions reduction resulting from national policies and measures biannually, up to 2020 separately as an obligation under the Energy Efficiency Directive and under the Monitoring Mechanism Regulation. From 2023 onwards both have to be reported in their national energy and climate progress reports (NECPRs) and this will result in a more close relationship in estimating (combined) impact on energy efficiency and on GHG emissions. Due to the inherent diversity of EU member states, there are several methodological guidance documents for energy savings (e.g. in the EED and the EPDB) and international standards and for GHG emissions reduction (in impact studies and papers produced by the EEA), but there is no universal methodology applicable for the varying sectors and policy measures and for combinations of policy measures.

So far, the Netherlands has mainly focused on national and sectoral climate targets which emphasise CO_2-emissions reduction (Rijksoverheid, 2019). There is no specific policy aimed at energy savings other than compliance with the European Energy Efficiency Directive (EED) Articles 3 and 7. Monitoring of the energy savings has been restricted to the main policies, as the impacts of these were sufficient to comply with the EED article 7 targets. Focussing on CO_2 emissions reduction complicates monitoring and reporting on energy savings, since not all GHG emissions reductions lead to energy savings and vice versa. In order to monitor energy savings, the Netherlands has decided to develop an integrated methodology with the greenhouse gas emission reduction that also has to be reported in the progress of the NECPR.

The Netherlands implemented more than fifty national policy measures such as subsidies, taxes, levies etc. resulting in energy savings in four sectors: the built environment, horticulture, mobility and industry (PBL, TNO, RIVM, CBS, 2021). It also has generic industry. Several cross-sectoral policy measures impact multiple sectors. Currently, the Dutch climate programme aims at a GHG emissions reduction of 60% in 2030 compared to 1990 and at the same time fulfil the energy savings obligations of the EU: 13% final energy reduction compared to 2020 and 1,5% per year, if these are to be adopted from the TheRePowerEU plan (Rijksoverheid, 2022).

This paper starts with discussing the general principles applied to calculate energy savings (below) and continues with a brief description of approaches applied for each of the four mentioned sectors. A summary of the method and type of data used is stated at the end of each sector. Next, the approaches applied for cross-sectoral policy measures are described. The last part of this paper deals with how double counting is avoided and the allocation of energy savings to sectors. It concludes with the approach used to determine GHG emissions reduction resulting from energy savings and the potential impact of electrification, CCS and hydrogen production on monitoring energy savings.

General principles for calculating energy savings in the Netherlands

The transition to a low-carbon economy is a dynamic and complex process, for which governments usually implement a package of policies. Individual policies usually don't suffice; only through the interplay of policy measures and stakeholder actions is decarbonization achieved. For this reason, progress in the Netherlands is monitored on a systemic level (e.g. electricity production, residential heating, etc.), corresponding to sectors and/or subsectors and not per individual policy measure.

Measurement methods

The energy savings realized as a result of policy measures are determined using technical estimates. Direct measurements are not used due to high costs. The following methods are typically used:

(i) For situations where standardized measures are taken, the numbers of measures taken are used in combination with the estimated average annual energy savings per measure. This applies for example to domestic heat pumps, LED lighting or electric vehicles. These deemed energy savings are determined using assumptions on the typical lifetime of the measures and the reference technology. The terms for the type of savings calculation can also be found in the EED article 7 and Guidance Notes to article 7 (European Parliament, 2018).

(ii) Energy savings through large projects, often unique in character (such as improving processes in industry), are usually calculated or measured on project-basis. These scaled energy savings are determined by comparing the (expected) new situation with the existing situation.

The reference is determined by the implementation of European policy and the application of minimum European energy efficiency and/or CO_2 emission standards. This is common for measures that replace a device, installation or vehicle at the end of its average lifetime. Additional energy savings will only count if the new device, installation and/or vehicle at the time of replacement is more efficient than the applicable European standards by then. This guarantees the additionality of the calculated energy savings in accordance with article

7 of the EED. If a device, installation and/or vehicle is replaced before the end of its usual life, then the situation without early replacement is the reference during the usual life of the replaced device, installation and/or vehicle (see figure 1).

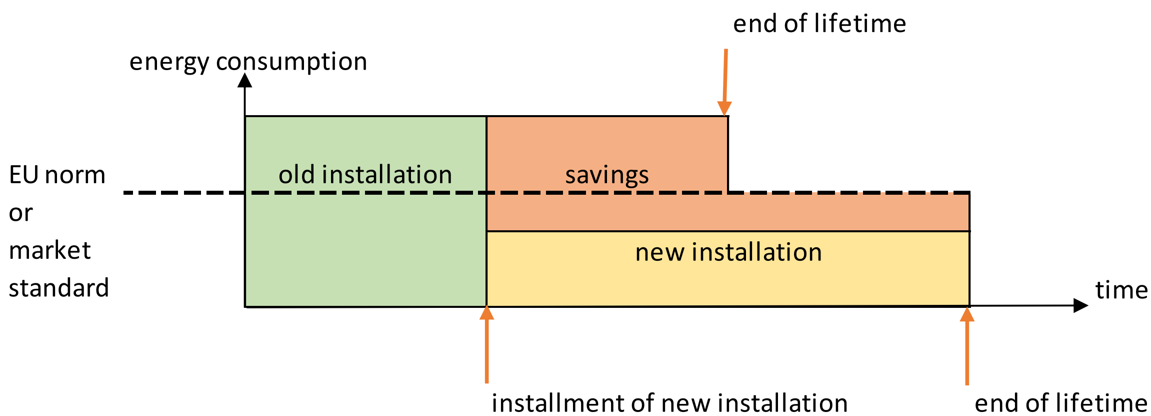

Figure 1: Schematic visualisation for determining energy savings in the case of early replacement

If no mandatory and/or concrete European standard is applicable, the reference is determined by the current standard in the market. If no data is available for the current standard in the market, (for example in the case of a specific process installation in industry), then a measure (or project) specific reference situation is used. An example of such a situation is the heat that is generated in an industrial process by using a heat pump. For this example, the reference technology is the equivalent natural gas boiler. The efficiencies used for such reference technologies are based on the efficiencies used by the Netherlands Environmental Assessment Agency (PBL) (Pişcă et al., 2021).

Energy savings from measures are counted from the year of implementation up to 2030, according to article 7 of EED. The lifetimes of the measures taken in the relevant sectors vary, but are mostly at least 7 years. For example, insulation measures generally have a service life of more than 20 years, vehicles more than 10 years and heating installations (such as high-efficiency boilers) approximately 15 years (Boonekamp, 2007). Only energy savings through behavioural measures, organizational measures and consumer electronics/equipment (including lighting) usually have lifetimes shorter than 10 years (Boonekamp, 2007). If such measures are taken, the savings caused by these measures are calculated based on the shorter lifetime. Energy savings are expressed as savings on final energy consumption, avoiding the need for primary energy conversion factors.

Sectoral approach for energy savings calculations

The sectoral energy savings in the Netherlands are influenced by both sectoral and cross-sectoral policy measures. Although several policy measures try to influence the same actor or target group, they often complement each other.

A. The built environment

The built environment sector consists of households and service sectors, and includes both building-related energy use and non-building use, such as appliances. Energy consumption by buildings in other sectors (such as industry and agriculture) is included in the respective sectors. Computer models are used to calculate energy savings for the built environment in the Netherlands. A distinction is made between the following subsystems:

(i) Building-related energy consumption by households (dwellings)

Building-related energy consumption is calculated by using the deemed savings method (Labanca & Bertoldi, 2016). In most cases, the reference situation for the deemed savings is the average efficiency per type of dwelling of a specific year. Only energy savings as a result of national policy are considered. To this end, the measures are compared with minimum European energy performance requirements (such as Ecodesign or building codes). The model used for these savings is SAWEC[1].

(ii) Household electricity consumption

For the technical estimate of the electricity consumption by households, the EVA[2] model is used. EVA analyses and calculates the energy use of lighting and appliances in a household both for the past and the future by using simulations. Input data is gathered through various sources such as surveys on market penetration of appliances, average use per appliance and statistics about the housing stock. The changes in energy use are calculated per type of appliance and per projected year in PJ electric and kWh.

(iii) Energy consumption service sectors

The SAVE[3] model is used to describe and analyse the development of energy consumption and energy savings in buildings in the Netherlands. To determine the energy savings, data on sales of measures (such as insulation, heat pumps, solar boilers etc.) as well as policy evaluations, behavioural studies and surveys is used.

Savings for the historical years (ex-post) are determined using the same methods as the savings in the scenarios (ex-ante) presented in the Climate and Energy Outlook (Klimaat en Energie Verkenning) of the Netherlands Environmental Assessment Agency (PBL)[4]. This means that the results for both the realization and the projections are mutually consistent.

A system approach is used for monitoring climate and energy policy in the built environment. A coherent package of policy measures, in addition to actions by other stakeholders, are the relevant key factors for the success of the transition. In the models described, when determining energy savings, the effect of the policy instruments is not considered separately, but the savings measures taken by households and services are considered as a combined package. The built environment has long been subject to high policy pressure in the various price incentives, legislation and incentive programmes. An important consequence of this is that substantial changes only take place autonomously when drastic events happen such as the gas price change because of the war in Ukraine. For example, before the war in Ukraine, there was hardly any profitable savings potential without the high energy taxes. To overcome barriers other than costs, policy intervention is almost always required.

Methodology and type of data used to calculate energy savings in the built environment

The main calculation method for energy savings for the built environment is through modelling. Market data on, amongst others, sales of insulation, heat pumps etc. is used as the basis for the calculation. The energy savings are the result of the entire package of policy measures and are not attributed to individual policy measures. This is because a target group can use multiple policy measures for the same savings, making a distinction per policy measure very challenging. A correction for autonomous developments is done by including behavioural studies and annual surveys in the calculations.

[1] https://www.pbl.nl/modellen/kev-rekensysteem-sawec

[2] https://www.pbl.nl/modellen/kev-rekensysteem-eva

[3] https://www.pbl.nl/modellen/kev-rekensysteem-save-services

[4] https://www.pbl.nl/kev

(B). Horticulture

For horticulture in the Netherlands, energy savings are achieved through new growing methods (*Het Nieuwe Telen*), energy-efficient lighting (LED) and new greenhouse concepts/materials, such as insulation. The remaining demand for natural gas is replaced with geothermal energy, (sustainable) electricity from the grid and heat from biomass, industry and the greenhouses[5]. In order to calculate energy savings, bottom-up data from the implementation of policy measures in horticulture is used. These measures are the *Marktintroductie energie-innovaties* (Market Introduction for Energy Innovations) MEI and *Regeling investeringen in energie-efficiëntie glastuinbouw* (scheme on energy efficiency and renewable energy in horticulture) EG. The MEI subsidy scheme is intended for investments in innovative energy systems for greenhouses that reduce CO_2 emissions and primary energy consumption. The EG scheme on energy efficiency and renewable energy in horticulture offers companies active in greenhouse cultivation a subsidy for specific measures for increasing energy efficiency, or generating and using renewable energy.

For the MEI, savings as a result of applying policy measures are estimated per project. Two years after implementation, monitored energy savings are also reported (kWh and Joules). For the EG, energy consumption data is provided before and after energy saving measures are applied. Calculations for the saved energy and change in CO_2 emissions can be done by comparing the data before and after the measures are taken.

Methodology and type of data used to calculate energy savings in the horticultural sector

The main calculation method for energy savings for the horticultural sector is through a bottoms-up approach: collected data on applicable policy measures for the sector (the MEI and EG) is used to calculate energy savings. The data provided consists amongst other information on the type of measures, the expected energy savings, energy use before and after implementation of measures.

C. Mobility

The Mobility sector entails road transport, rail transport, inland shipping and aviation. The mobility sector includes the energy consumption of all modes of transport and mobile equipment in the various sectors such as agriculture & fisheries, industry and the service sector. International navigation and aviation are not included in the energy savings calculations.

Energy savings by mobility in the Netherlands is calculated using technical estimates and is determined for two types of measures: sales of electric vehicles and through modal shift.

(i) Sales of electric vehicles

For savings based on electric vehicles, savings are determined by comparing the annual energy consumption of new vehicles sold with the energy consumption of new vehicles sold in a situation without national policy. This reference situation is based on the European standard for CO_2 emissions, calculated for energy consumption. For two-wheelers (petrol), vans / trucks / tractors / buses (diesel) there is often one fuel that is used, making the calculation of CO_2 emissions per km to MJ per km relatively simple. A mix of fuels is possible for passenger cars; petrol, diesel, LPG, CNG, BEV and PHEV. In order to convert back from the CO_2

[5] Greenhouses are plastic and glass buildings, common in the Netherlands, that are used for cultivation of plants by applying the greenhouse-effect: trapping the heat from the sun to create a warmer environment within the greenhouse so that plants can thrive.

standard to energy unit, the fuel mix of new sales must be taken into account. Due to a lack of data on the vehicle to be replaced, savings from early replacement are also compared to this reference situation. The realized savings are calculated on the basis of data on, among others, driven kilometres and fuel consumption per kilometre. Savings are determined both on the basis of new sales and on the basis of a shift in the number of kilometres driven per modality. The sum of the savings in the following modalities are the total savings for the mobility sector in the Netherlands: road transport, two-wheeler, passenger car, van, truck/tractor, bus, mobile tool, railway, inland shipping, and inland aviation.

By focusing on new sales, a clear reference can be determined, namely the European CO_2 standards for vehicles. However, vehicles are also added to the Dutch fleet via import of second-hand vehicles. These are largely young vehicles (< 5 years). The methodology for taking imports into account is still being developed.

(ii) Modal shift

Energy savings associated with a reduction, or modal shift concerns the number of kilometres travelled of the total vehicle fleet per modality. Goods transport includes modalities of delivery vans, trucks/tractors, inland shipping and rail. It is expressed in the number of tonne-kms (year T compared to year T-1). Passenger transport includes the modalities of train, bus, car, two-wheelers (scooter, motorcycle, electric bicycle, bicycle) and walking; it concerns the number of passenger kilometres. The reference for the number of tonne-kms e.g. developments in load factor and modal shift: the number of tonne-kms is compared to the number of tonnes transported. The relative decrease in the number of tonne-kms is regarded as a saving. The reference for number of passenger kilometres is determined on the basis of commuter surveys (Rijksoverheid, 2021). Inquiries are made about the reduction in the number of vehicle kilometres and what the underlying reasons are for the reduction (ibid.). Based on this, an estimate can be made of which part of the energy savings is caused by national policy.

Methodology and type of data used to calculate energy savings for the mobility sector

The main calculation method for energy savings for the mobility sector is through bottom-up technical estimates. The realized savings are calculated on the basis of data on, amongst others, driven kilometres, fuel consumption per kilometre, sales of new passenger vehicles etc. Surveys are used in order to account for modal shifts.

D. Industry

The industry sector includes the manufacturing industry and energy industries (not utilities), waste management and water utilities. In the Netherlands there are no clearly defined policy measures specifically designed for the industrial sector that provide monitoring data from which energy savings can be determined. Up to and including 2020, the multi-year agreements (LTAs) on energy efficiency were one of the most important policy measures to stimulate energy saving in industry; however, these agreements expired at the end of 2020 and thus no longer provide data to calculate energy savings. Some projects in the agreements were not fully implemented within the given time period (end of 2020). The energy savings resulting from these projects will be included in the savings for the industry sector for 2021-2030. Currently, some policy measures are undergoing changes to make sure that monitoring data for energy savings is provided. This is the case for the *Informatieplicht* (information obligation) and the *Onderzoeksplicht* (investigation obligation) which are obligations for companies meeting certain criteria having to investigate and apply all energy-savings measures that have a pay-back period of 5 years or less. Additionally, energy savings for the industrial sector are based on the cross sectoral policy measures: *EIA, ISDE* and the *SDE++* discussed below.

Generic policy measure approach

Some policy measures are generic in nature and are therefore important for energy savings for multiple sectors. Most important for saving energy are the *Investeringssubsidie Duurzame Energie en energiebesparing* (Investment subsidy for sustainable energy and energy saving) ISDE, *Energie-Investeringsaftrek* (Energy investment deduction) EIA, and *Stimulering Duurzame Energieproductie en Klimaattransitie* (Stimulating Sustainable Energy Production and Climate Transition) SDE++. The approach to calculate energy savings from these cross-sectoral policy measures are described below.

***ISDE*- The Sustainable Energy Investment Grant**

The *ISDE* is a financial contribution for the purchase of solar boilers, heat pumps and from 2021 also for insulation measures both for individuals and for business. The goal of the ISDE is to encourage Dutch households and companies to use less natural gas and more sustainable heat, leading to energy savings and reduction in CO_2 emissions.

The main calculation method for energy savings for the *ISDE* is through bottom-up calculations with the data in the subsidy. Data is available on the (thermal) capacity of the installations, the expected heat production and electricity consumption. The energy savings are determined using assumptions on typical energy savings per technology.

The thermal capacity of the subsidized heat pumps is known per project for both ground-source and air-source heat pumps. The expected heat production and the required electricity consumption are determined using assumptions on typical energy savings per technology. The difference between them (the consumption of ambient heat) is counted as savings on the final consumption of natural gas.

For the subsidized solar boilers, the thermal capacity is also known per project. The heat production per solar boiler is an assumed average production that varies according to the aperture area. This assumed production for systems up to 10 m^2 is corrected for the annual share of heat not obtained from solar energy according to the product card and the supplementary electricity consumption according to the product card. For systems larger than 10 m^2, the heat production depends on the total collector surface, the collector efficiency, the irradiation angle modifier and the loss factor of the hot water tank. The heat production is counted as a saving on the final consumption of natural gas.

***EIA* - The Energy Investment Allowance**

The *EIA* (*Energie Investeringsaftrek*) is a tax scheme that provides an additional deduction option for a company's taxable profit. This option can be used to purchase designated energy-efficient operating assets, operating assets that generate sustainable energy and operating assets for energy balancing and energy transition (such as electrification). The EIA enables companies to deduct 45% of the investment amount from the taxable profit, so that less tax has to be paid. Assets that meet the generic savings standards of the EIA are eligible for support and are included in the annually updated energy list.

The main calculation method for energy savings for the EIA is through bottom-up calculations with the data in the application about the type of technology. The energy savings are determined using assumptions on typical energy savings per technology. The energy-efficient equipment must save energy compared to what is current on the market at the time of purchase. This reference meets at least the current European CO_2 or energy performance standards, so that extra energy can be saved with the designated operating resources. Business assets for the generation of sustainable energy using biomass are eligible for EIA if they generate the energy more efficiently than usual.

***SDE++* - Stimulating Sustainable Energy Production and Climate Transition**

The SDE++ is a subsidy scheme for businesses and non-profit organisations which want to produce sustainable (renewable) energy on a large scale, or which want to apply CO_2-reducing techniques. The SDE++ covers the unprofitable part of each technology: the difference between the cost of the technology that reduces CO_2 and the market value of the product generated by the technology. The base rate is fixed for the entire subsidy period, but the corrective amount is set annually. The unprofitable component decreases when the market value rises, as does the amount of the subsidy one receives. Subsidies are granted for periods of 12 or 15 years. The duration of the subsidy depends on the technology used (RVO, 2022).

The SDE++ is open for the production of renewable electricity, renewable gas and renewable heat or a combination of renewable heat and electricity (CHP) from biomass, geothermal energy, water, wind and solar and, since 2021, also for CO_2-reducing technologies. Many of these techniques can also reduce the final energy consumption, either through the production of sustainable energy behind the meter or through more efficient production.

Technical estimates are used for both the realized (ex-post) and expected (ex-ante) energy savings. An estimate can be made of the expected energy savings on the basis of data in the subsidy decision, in which the maximum annual productions that are eligible for subsidy are stated. The realized energy savings can be determined on the basis of registered production data. In the case of the SDE++, the subsidy to be paid is based on certified productions. Data about certified renewable electricity and heat productions, together with green gas productions are available. Savings on the consumption of heat are calculated as the avoided consumption of natural gas that produces the same amount of heat (based on net value) and is expressed in kWh final consumption.

Allocation of energy savings to sectors and avoiding double counting

Allocating of energy savings to sectors

Energy savings for the Netherlands are divided over the sectors: built environment, mobility, horticulture and industry. Chamber of Commerce (KvK) numbers and the sectoral NACE classification codes provided with each project are used for the allocation. This is done by linking all reports of the SDE++, ISDE and EIA schemes based on the sectoral NACE code to a sector. After the sectoral allocation, double counting is accounted for.

Accounting for double counting

Double counting for energy savings can occur due to overlaps between the cross sectoral policy measures and the energy savings determined for each sector. Overlaps can also occur among cross-sectoral policy measures and between sectors.

Cross sectoral policy measures:

Overlap can arise when the same measures use both a subsidy (SDE++ or ISDE) and a tax advantage (EIA or MIA\VAMIL). To avoid double counting, savings from the EIA or MIA\VAMIL of the same year, done by the same company and occur at the same physical location are only counted once.

Built environment: To avoid double counting for the built environment, energy savings in the service sector and by households resulting from the SDE++, ISDE, EIA and MIA\VAMIL are not counted, since they are included in the modelling. To avoid double counting between the built environment, non-residential construction in industry and with agriculture, the energy savings in utility buildings which are determined on the basis of the policy measures for industry and agriculture are not counted. It is assumed that the energy savings determined for the built environment (based on sales data) provide a more comprehensive dataset to determine energy savings in the service sector and by households compared to the data than can be derived from the specific policy measures for those subsectors.

Mobility: To avoid double counting for the mobility sector, the energy savings determined for the EIA as a result of electric vehicles and mobile equipment are not included in the energy savings for mobility.

Industry: The cross sectoral policy measures resulting in energy savings by industry may overlap with energy savings from future policy measures (*Onderzoeksplicht* and *Informatieplicht).* At the moment it is challenging to define how to account for overlap. In case the policy measures are able to provide more detailed information than the generic measures, then the savings from cross sectoral policies that can be linked to companies that have submitted a report for the same year and location will not be counted.

Horticulture: The cross sectoral policy measures result in energy savings for agriculture, which partly overlaps with energy savings from specific policy measures for the horticulture sector. It is assumed that the horticulture measures provide a more complete picture of the measures taken than the generic policy measures. Therefore, savings from the generic policy measures that can be linked to EG or MEI applications for the same year and the same location are not counted.

The interaction between greenhouse gases and energy savings

CO_2 emission reduction from energy savings

A challenging part of the calculation methodology for energy savings in combination with CO_2-emissions is that not all GHG emissions reduction lead to energy savings. Energy savings however result in the avoidance of (fossil) energy consumption (electricity, natural gas or gasoline/diesel). In order to calculate the avoided CO_2 emissions from energy savings, the emission factor is multiplied with the amount of energy produced avoiding the consumption of fossil fuels. Data on the (avoided) energy carrier are collected during the monitoring of policy measures.

Electric vehicles consume electricity and avoid the consumption of gasoline and/or diesel. This results in the reduction of CO_2-emissions, calculated using the emission factor for gasoline and diesel. Due to additional electricity consumption, CO_2-emissions increase in the electricity sector. The emission factor for electricity depends on the fuel-mix and conversion efficiency of domestic production. Possible impacts of energy savings on the import or export of electricity are not taken into account.

Energy savings on natural gas and electricity consumption that is replaced with renewable energy production in or on the building itself (such as from solar panels and heat pumps), are counted as energy savings.

Implications of electrification, CCS and hydrogen production on monitoring energy savings and GHG emissions reduction

The level of complexity for energy savings seems to increase with the increased ambitions of the Dutch government with regards to electrification, (green) hydrogen production and carbon capture and storage (CCS) (Rijksoverheid, 2022).

Increased electrification for the mobility sector and industry for example is a fuel switch which leads to increase in (clean) electricity demand (Hers et al., 2022). Until all needed electricity is renewable, a shift in CO_2-emissions allocation takes place, at the moment from the mobility sector to the EU-ETS sectors. For mobility however, the fuel switch leads to increased savings as well as decreased CO_2-emissions because the tank to wheel efficiency is higher for electrical cars than for cars with an internal combustion engine.

Carbon Capture and Storage (CCS) generally leads to less CO_2-emissions to the atmosphere because the CO_2 is captured. The process however is energy intensive and leads to an increase in energy demand (Delft, 2018). With fluctuating CO_2 prices for the emission trading system, the total amount of CO_2 captured can fluctuate as well. In order to maximise energy savings, one would plead for CCS with renewable energy, or better even, to mitigate processes that lead to increased CO_2 emissions and the need for CCS in the first place.

Currently, the hydrogen used in the Netherlands is mainly derived from fossil fuels (Hoogervorst, 2020). The Dutch government has ambitions to increase the total hydrogen generation, including hydrogen produced from (electrolysis of) water. Production of hydrogen leads to an increase in electricity demand, which can be (partially) met with increased offshore electricity production. This additional puzzle has an effect on the total CO_2 generation depending on the resources used for hydrogen production and the source of the energy during the production.

Discussion and Conclusion

Choosing to approach energy savings calculations as done for the Netherlands brings a number of strengths and weaknesses with it. The choice for a systems-wide approach is advantageous because it leads to inclusion of policy measures that are instrumental for the success of a group of policies but which when observed individually might seem to have marginal effect. There is therefore more attention to the interactions within policy measures. On the other hand, a systems-wide approach also leads to extra steps that have to be taken when compared to an individual policy measure approach. Accounting for double counting is for example much more important when policy measures are bundled together than when an individual measure is considered.

The chosen approach relies heavily on bottom-up data in order to report on energy savings and GHG emissions reduction. This approach is quite challenging because it is heavily dependent on good data collection and a well-established monitoring system. While the Netherlands is striving to collect as much essential monitoring data as possible, not all policy instruments allow for it at the moment. This is for example the case for policy measures in the industry sector such as the *informatieplicht* and the *onderzoeksplicht*. In these policy measures, energy savings technologies with a pay-back period of five years or less have to be implemented. However, the current regulations for these two measures do not stipulate that the energy savings have to be reported to a governmental agency for monitoring and verification, only that energy saving technologies have been applied. Therefore the savings at the moment are not reported and cannot be taken into account. As stated in the industry section, the two abovementioned policy measures are being adjusted so that monitoring data can be collected.

As usual, stepping from theory to practice is commonly unruly. The same stands for applying this methodology in practice. Data for policy measures in the Netherlands is usually managed and stored within the team of the agency that manages the policy measure. When collective reporting needs to be done, as is the case for national energy savings and GHG emissions reduction, data has to be gathered from many different places and has to go through multiple people and processes. This is an inefficient and time-consuming process, especially when data has to be extracted from individual reporting documents from subsidy schemes for example.

The same difficulty applies when no common data collection formats are initially used for the different policy measures. At the moment, administrative data for a subsidy application is not collected in the same place as the monitoring data, which is also not collected uniformly. In order to process all the monitoring data, much effort is required to streamline the different data flows and especially when accounting for double counting.

At the moment, the Netherlands Enterprise Agency, the governmental organ which conducts and manages a large portion of the policy measures for energy savings, is changing the data management structure. By gathering all necessary data in an enterprise data warehouse, monitoring, data processing and reporting should become less cumbersome.

As noted in the previous chapter, the level of complexity increases when accounting for energy savings in combination with CO_2-emissions. One would plead for more system-wide policy focus on energy savings in order to mitigate this rising complexity.

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