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Impact assessment of the LABELS concept

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Samenvatting

Er is groeiende interesse onder consumenten (groot en klein) om elektriciteit te kopen waarvan het aantoonbaar is waar het vandaan komt en hoe het geproduceerd is bijv. dat het gaat om windenergie uit Nederland of lokaal geproduceerde zonne-energie. Consumenten willen deze energie gebruiken wanneer het geproduceerd wordt en daar een bewijs van krijgen. Een manier om dat te regelen is de oorsprong van deze energie vast te leggen in betrouwbare certificaten voor de desbetreffende uren en deze certificaten te koppelen aan de handel in energie. Dit concept is getoetst in het TKI UE project LABELS, een samenwerkingsverband van ETPA, Eneco, KPN en TNO.

In deze impact assessment studie is onderzocht wat voor effect vraag naar het label ‘groene elektriciteit uit Nederland’ heeft op de business case voor flexibiliteitin een 2030 scenario. Er is gekeken naar

- De bijdrage van het LABELS concept aan de matching van gelabelde vraag met aanbod. Onder welke omstandigheden kunnen welke proposities richting een klant worden waargemaakt?
- De bijdrage van het LABELS concept aan de business case voor flexibiliteit. Zorgt het handelen in gelabelde energie voor extra vraag naar flexibiliteit?

Er is niet gekeken naar twee andere mogelijk positieve effect van het labelen van energie:

- de impact van het LABELS concept op de business case voor duurzame energie en de groei van duurzame energie in Nederland. Het inzicht dat deze studie biedt in de bijdrage van het LABELS concept aan matching van gelabelde vraag en aanbod geeft wel inzicht in de mogelijkheden voor nieuwe proposities. Deze uitkomsten kunnen gebruikt worden om de impact op de business case voor duurzame energie te evalueren wanneer ze worden gecombineerd met inzichten over de bereidheid van consumenten (bedrijven, individuen) om meer te betalen voor (lokale) duurzame energie die matcht met hun consumptieprofielen.
- de bijdrage van het LABELS concept aan de transparantie en reductie van transactiekosten door de elektriciteits- en de certificatenhandel te koppelen.

De uitkomsten van de studie laten zien dat de hoeveelheid gelabelde energie die je kunt matchen met je vraag sterk afhankelijk is van de totale vraag naar gelabelde energie. Als een partij bereid is extra te betalen voor groene elektriciteit dan andere partijen kan een matching van ongeveer 95% worden bereikt. Dit betekent dat de consument gemiddeld op elk uur van de dag 95% groene energie (wind en zon) uit Nederland krijgt.[1] Als echter half Nederland voor dezelfde prijs bereid is te betalen voor deze ‘groen’ gelabelde elektriciteit daalt dit naar 70%.

Individuen kunnen de matchingsscore ophogen door meer te betalen voor gelabeldeenergie, maar dit betekent ook gelijk dat de score van de partijen die minder betalen naar beneden gaat. Voor aanbieders van ‘gelabelde energie’ (flexibiliteitsaanbieders en leveranciers) is het belangrijk om deze dynamiek te

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[1] Daarbij is het uitdrukkelijk niet toegestaan om op één uur een score te behalen hoger dan 100%.

begrijpen: 100% groene energie garanderen kan nog bij de eerste klanten, maar bij grootschalige afname van gelabelde energie zal de verwachting van het gros van de klanten moeten worden bijgesteld.

Hoewel er zeker ruimte is voor het ontwikkelen van gelabelde energiediensten, is er op grote schaal is er in de LABELED energiemarkt in 2030 een stuk minder rendement te behalen: het aantal uren waarop er een overschot van duurzame elektriciteitis, is nog te beperkt. Ook wordt er verwacht dat hybride flexibele installatieszoals hybride boilers of electrolyzers groene energie zullen inkopen middels lange termijn contracten waardoor er meer energievraag wordt toegevoegd en er tegelijkertijd minder groene energie beschikbaar is voor andere gebruikers. Dit effect is niet meegenomen in de analyse, hoewel het LABELS concept voor electrolyzers interessant kan zijn om groene waterstof ook te certificeren als zodanig.

In het 2030 scenario, dat al optimistischer is dan het Klimaatakkoord is er nog niet voldoende duurzame energie om alle vraag te voorzien. Dit zorgt ervoor dat als meer dan 50% van de consumenten gelabelde groene elektriciteit willen flexibiliteitsaanbieders geen meerwaarde kunnen bieden. Wanneer de hoeveelheid duurzame energie verdubbelt ten aanzien van het 2030 scenario zien we een omslag: er is over een heel jaar voldoende. In dit scenario zal een gelabelde energiemarkt juist bijdragen aan de hoeveelheid benutte duurzame elektriciteit en is de rol van flexibiliteit onmisbaar.

Inhoudsopgave

1 Introduction

There is an increasing interest among consumers of electricity to buy green or locally produced energy that is supplied to the grid at the moment of actual consumption. To enable this the LABELS concept is developed in this project. According to this concept consumers can buy certificates linked to electricity offers, so they match on location, source and time. In other words: consumers buy electricity of a certain LABEL.

With the LABELS concept implemented in one or more electricity markets platform, actual new commodities are introduced. Consumers are not just interested in buying electricity, but may have a preference to buy electricity of a certain LABEL e.g. green electricity or electricity from a certain location.

In this impact study we study the impact of the introduction of one such new commodity, (hourly matching) green electricity from The Netherlands: NLGREEN. We study the potential – the hourly matching score between production and consumption - that is available for consumers and the business opportunities for flexibility providers on the new market. The NLGREEN electricity market is expected to be the most important and largest LABELED energy market. Studying this market will give also insights in the impact of other LABELED energy markets such as markets for locally produced (green) electricity.

Green electricity defined as produced by wind or solar energy is not always available. In the definition of the label NLGREEN, supply from a storage unit filled with NLGREEN electricity only is also considered to have the label NLGREEN. If a consumers wants to consume green electricity only, he needs 1) to consume only when green electricity is available (by using his flexibility) or 2) to consume energy from a storage that is filled with ‘green’ energy at another moment. Both types of flexibility have an added value for consumers willing to buy (almost) only NLGREEN.

The impact of the LABELS concept is assessed in an energy market simulation of the 2030 Dutch electricity market. The results that are looked at are:

- The change in green energy matching score for individual or groups of consumers when they buy NLGREEN instead of ‘market mix’ electricity.
- The market potential for flexibility when a set of consumer prefers NLGREEN over ‘market mix’ electricity.

The result of the impact assessment provides an insight in the dynamics of the NLGREEN market. If many consumers are having the same willingness-to-pay price for green electricity, everyone gets less of the cake. A situation where 50% of the consumers is willing to pay extra (which means, willing to pay the costs of storage) seems to be most optimal. When more people are paying high prices for green electricity less green electricity supply is available.

In the 2030 scenario during 1200 hours per year 5 TWh of green electricity supply surplus is expected. This amount of electricity can be stored and provided to consumers willing to buy NLGREEN electricity or be used by flexible demand e.g. electrolyzers, hybrid industrial heat pumps or can be exported.This means that it is possible to provide 50% of the demand in the Netherlands with NLGREEN, but only if consumers are willing to buy NLGREEN electricity for its price: .the willingness-to-pay price of these consumers should exceed the bid price of flexible assets such as electrolyzers and hybrid industrial heating and should overcome the costs of storage.

In 2030 the amount of installed flexible assets (hybrid heating and electrolyzers) is expected to be large enough to consume almost all renewables surplus. Therefore the proposition of offering LABELED (NLGREEN) energy services for flexibility is expected to be more a niche market: only if the cost is low (e.g. simple demand response actions without changing the comfort or revenue of the consumer) or when the consumer has a high willingness-to-pay for electricity labeled as NLGREEN (see Section 3.5).

2 Methodology

The impact of the LABELS concept on the business case for flexibility is evaluated in several experiments using the EYE simulator. EYE has been developed by TNO to simulate the behavior of wholesale (day ahead) energy markets. EYE provides input for the evaluation of business cases of (industrial) flexibility assets[2]. For the evaluation of the LABELS concept, a new functionality is added to the EYE tool: the option to add markets on which only energy with certain LABELS (e.g. 'NLGREEN') can be traded.

In the experiments the following is evaluated:

- the market potential for flexibility in a NLGREEN electricity market: for what price can what flexibility volume be cleared at a green electricity market?
- the number of operating hours of a battery that is trading on a NLGREEN electricity market compared to a battery trading on an 'unlabeled' market.
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Although the evaluation is limited to explicit flexibility, the results can be used to evaluate the impact of the LABELS concept on the business case for implicit flexibility: a consumers that prefers NLGREEN electricity can use his own flexibility (storage or demand response) to match supply of green energy with his demand.

2.1 Assumptions about the implementation of the LABELS concept

The LABELS concept can be implemented in various ways. It is expected that first 'simpler' approaches will be implemented before a full LABELS concept is rolled out. A few stages are distinguished by the consortium:

- Bilateral trading of LABELED energy (e.g. via PPAs, ex-post matching).
- A concept with direct settlement of energy and certificates Therefore in this solution there is a focus on an official (national/EU) certification/verification of LABELED supply. The solution ETPA has developed in the LABELS project is in line with this implementation approach. Also the TNO demo "LABELS experience' shows how this can work.
- Settlement ex-post. In this approach demand and supply are officially matched. In this case also demand is certified as a 'green consumed'. This concept is developed and demonstrated in a preceding concept development project.

The impact assessment evaluates the full potential of all three options. The first option is probably less able to optimize the full (economic) potential since it relies on optimization of bilateral contracts.

2.2 The scenario

In this study we use a scenario for 2030 that was defined by consulting several studies from e-Risk[3], PBL[4,5] and TNO expert knowledge. This scenario has higher

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[2] The evaluation of flexibility business cases is limited to hourly energy products in MWh e.g. day-head. Therefore the tools does not evaluate the business case for e.g. balancing products.

[3] Modellering van industriële flexopties, e-Risk, TKI Hybrid Energy Systems, 2018

[4] Tabellenbijlage nationale energieverkenning 2017, PBL, 2017

[5] Achtergrondrapport elektriciteit van klimaatakkoord, PBL, 2018

estimations of renewables compared to the Klimaatakkoord. The asset capacity in Table 1 is shown in peak capacity of the asset. The total yield of renewable assets can be calculated using the yearly profile with resulting operational hours.

Table 1 The 2030 scenario (updated: May 2019)

	2020	**2025**	**2030**
Energy Mix	***GW***	***GW***	***GW***
Wind Onshore	5,4	6,8	8,1
Wind Offshore	2,4	8,5	14,5
Solar	5,3	13,2	21,1
Natural Gas	13,9	13,8	11,9
Nuclear	0,5	0,0	0,0
Coal	5,0	4,3	0,0
Hydrogen	0,0	0,4	1,6
Biomass	0	0	2,5
Demand	**GW**	**GW**	**GW**
Demand	19,5	19,6	22,9
Flexibility Options	**GW**	**GW**	**GW**
Hybrid Boiler	0	0,96	1,50
Heat Pump	0	0,82	1,40
Power-2-Hydrogen	0	0,50	1,90
Storage	0	1,22	2,04
Commodity Prices	**€/MWh**	**€/MWh**	**€/MWh**
Gas price	19,4	27,7	35,6
Coal price	7,6	8,6	9,7
Biomass price	N/A	N/A	31,3
H2 price (from SMR)	31,9	46,9	61,1
	€/ton	**€/ton**	**€/ton**
CO2 price	18	31	43

Conventional production

The installed power plant capacity (Natural gas, Nuclear, Coal, Hydrogen and Biomass) is based on TNO expert interviews[6]. Based on these interviews, information on 99 power production assets is documented.. The overall power plant development, shown in Figure 1, assumes phasing out of nuclear energy in 2025 and energy generated by coal plants phased out in 2030. In the 2025 scenario one asset of the Magnum power plant is converted to hydrogen, with the full power plant converted by 2030. In 2030, 8 assets are converted from coal to biomass. In the current and future system, the scenario contains 5,2 GW of must-run capacity from CHP's and assets that supply heat grids.

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[6] See Supplement 7.6

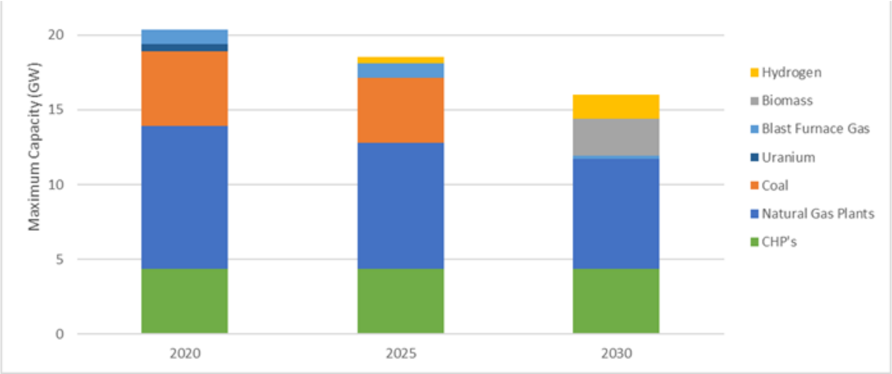

Figure 1 Installed power plant development in the BAU scenario.

Demand (all sectors)

The national base load demand in TWh is based on an average between the studies of ECN.TNO and e-Risk, the Nationale Energieverkenning 2017, CE Delft[7] and FLEXNET[8]. This leads to a demand of 119.5 TWh in 2020 and 139.8 TWh in 2030. Input in EYE is based on hourly peak demand. The yearly demand and the peak demand are related through the yearly demand profile. The yearly demand profiles in EYE are calculated by using the base year of 2017, this profile is shown in Figure 4. The energy demand assumptions are summarized in Table 2.

	2016	**2020**	**2025**	**2030**
Demand	113 TWh	119.5 TWh	120 TWh	139.8 TWh
Peak Demand	18 GW	19 GW	19.1 GW	22.3 GW

Table 2 Summary of energy system base case assumptions. The peak demand is the hourly peak demand.

Flexible assets

In BAU scenario four flexibility options were added: Hybrid Boiler, Heat Pump, Power-2-Hydrogen and Storage. For the 2030 scenario we used the assumptions from FLEXNET as shown in Table 3.

	MW installed
Power-2-Ammonia	0.870
EV	2.043
P2H	2.972
P2G	1.074

Table 3 FLEXNET assumptions A2030 scenario in MW.

For Power-2-Hydrogen we assumed the sum of P2A and P2G. For storage the full electric vehicle capacity. The amount of Power-2-Heat was divided in 55% for

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[7] Scenario-ontwikkeling energievoorziening 2030, CE Delft, 2014

[8] The demand for flexibility of the power system in the Netherlands, 2015-2050, ECN, 2017

Industry Boiler and 45% Industry Heat Pump[9]. The amount of flexibility options in 2025 has been scaled to the increase in renewable energy in the system.
The amount of flexibility in the system is highly uncertain and will mostly be a variable input in EYE runs. The scenario as depicted in Table 3 should therefore be viewed as a validation scenario.

Power prices
As the installed base of power plants are dependent on fuels, the fuel price will determine a large part of the electricity price. As these prices are dependent on their own market mechanisms (long-term contracts, it is difficult to predict the commodity prices in the future. Therefore, we chose to adopt one scenario of fuel prices as used by PBL[5].

This leads to the energy prices of natural gas, coal and CO_2 as shown in Table 1. The hydrogen price is based on the price of producing hydrogen from SMR. To calculate the price, we used the natural gas price, an efficiency of 72% and a CO_2 footprint of 0.27 ton/MWh Hydrogen. The price of biomass was based on estimating the 2030 biomass (wood pellet) price to be € 130/ton[10] with an energy content of 15 GJ/ton.

2.3 Description of the Eye model

EYE is a simulation tool that can simulate expected electricity prices on wholesale markets based on a scenario. To do so, EYE is using bid ladders (merit orders) of supply and demand, coupled with a clearing mechanism (marginal pricing) that is comparable with the clearing mechanism of wholesale markets.

Definition: The merit order is a way of ranking available sources of energy, especially electrical generation, based on ascending order of price (which may reflect the order of their short-run marginal costs of production) together with amount of energy that will be generated. In a centralized management, the ranking is so that those with the lowest marginal costs are the first ones to be brought online to meet demand, and the plants with the highest marginal costs are the last to be brought on line. Dispatching generation in this way minimizes the cost of production of electricity.

EYE can determine an expected price for a given time unit (typically hourly). It is possible to run simulations based on future energy system scenarios and, as a result, analyze the behavior of future energy prices. An overview of the EYE simulator and its inputs and outputs is shown in Figure 2.

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[9] This division was made based on an analysis of industrial high temperature demand in the food and paper industry that is suitable for industrial boilers (55 PJ) and industrial low temperature (<100 degrees) demand suitable for heat pumps (45 PJ).
[10] 2017 ECN found 155 €/ton with a downward trend, Kostenonderzoek verbranding en vergassing van biomasse SDE+ 2018, 2017

Figure 2: Overview of EYE simulator with inputs: models of demand and supply bid behavior, and outputs such price and production/consumption profiles of individual assets.

LABELS market functionality
For the evaluation of the LABELS concept a new functionality is added to the EYE simulator: an option to add markets on which only energy of a certain LABEL can be traded. For the Impact Assessment only 2 electricity markets are simulated: a green (label: NLGREEN) and an unlabeled market, but it is possible to add multiple markets for multiple LABELS.

The NLGREEN and unlabeled market are cleared sequentially. For the experiment we assumed that the green electricity market is cleared first: consumers try to buy green electricity first before they try to buy unlabeled electricity.

2.4 Sector profiles

In the world of LABELED electricity the profile of the consumer matters. Therefore the profile of the Dutch demand (see Section 2.2) is disaggregated using a bottom-up approach. The correlation between the bottom-up defined profile (Figure 3) and the aggregated profile (Figure 4) is 54%. Since the results in the simulation are similar (similar prices), this is good enough for the impact assessment.

Sector	**Profile source**	**PJ/y**
Built environment	NEDU (E1A 80%, E2A 10%, E3B 10%)	190
Industry	TNO (50% continuous, 50% day)	155
Mobility	TNO (10% fast, 40% public, 50% private charging)	14
Agriculture	continuous	48
Electricity	continuous	21

Table 4 Profiles used to model the demand of various sectors and the total demand of the sector[11].

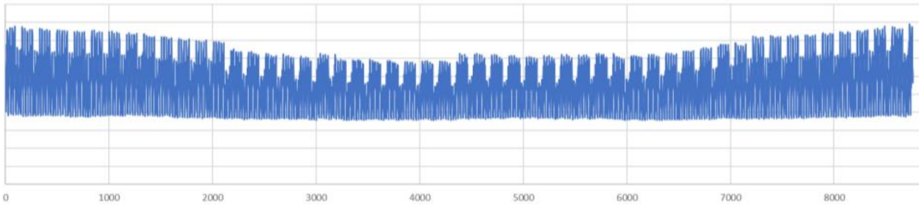

Figure 3 Bottom-up defined Dutch electricity demand profile. Using the profiles in Table 4.

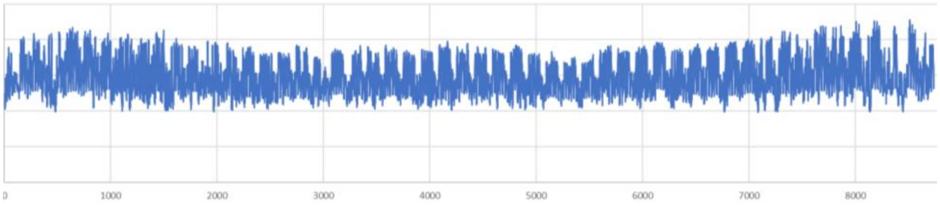

Figure 4 Dutch electricity demand profile for 2030.

The profiles of TNO (5 buildings) and KPN (1 location, representable for 160 similar KPN locations) are also added to the simulation.

2.5 Setup of the experiments

For the evaluation of the impact of the LABELS concept on the business case of flexibility assets several experiments are setup. First settings used in all experiments are described, after that the goal and setup and output of each experiment is described.

General setup parameters
For the modelling of the unlabeled market the 2030 scenario market is used. Certain assets bidding in this markets are also added to the NLGREEN electricity market. Solar, wind and selected storage assets are added as are parts of the demand (this differs per experiment). The bid price of consumers in the NLGREEN electricity market is higher than on the Unlabeled market.

Battery characteristics
In each scenario a battery is added, as an example flexibility asset for which the number of operating hours is evaluated. KPN has placed a NiMH[12] battery on a pilot location, this type of battery is used for the evaluation. The specifications of this battery are assumed to be representative for all batteries that in the future will be placed on 160 similar locations. The specifications of the battery are:

- 4 packs of 57,5 kWh, so a total of 230 kWh
- DoD = 100
- Losses over lifetime = 20%
- Preferred charging rate under normal conditions is 0.3C
- Under 3C, number of cycles is 12k

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[11] KEV 2019, Table 8
[12] Nilar EC

- Self-discharge in one day 6%, after 28 days 13%
- Cost = 200k

The battery set is modelled as a Virtual Battery combining the theoretic capacity of all the batteries in all 160 locations.

Experiment A – No LABELS
This is a simulation of the 2030scenario without a market for NLGREEN labeled energy. The result of this experiment is the matching of demand with renewable supply when the LABELS concept is not implemented. Another result of this experiment is the number of operating hours for flexible assets in the2030 scenario without a market for labeled energy.

Experiment B – Availability of green electricity and flexibility potential
The Netherlands has in 2030 approx. 22,9 GW hourly peak demand. In this experiment is explored what happens if 10% or 90% of this load is from parties that prefer hourly green matching energy labeled as NLGREEN always over buying from an unlabeled market. What is the NLGREEN matching score of these consumers and what is the storage potential? In this experiment it is assumed that all consumers are willing to pay the same price for green electricity and that this price is high enough to supply the demand from storage.

Experiment C – Willingness-to-pay and business case for flexibility
If consumers in experiment B have different willingness-to-pay prices the NLGREEN matching score of individual consumers changes. In this experiment we explore how this works and what the effect is on the business case for flexibility.

3 Results

This section presents the results of the experiments introduced in Section 2.

3.1 Experiment A – No LABELS

The ‘market mix’ resulting from the 2030 simulation contains renewable energy. When the LABELS concept is not implemented 46% of the demand of all consumers in the Dutch electricity market is supplied as green electricity.

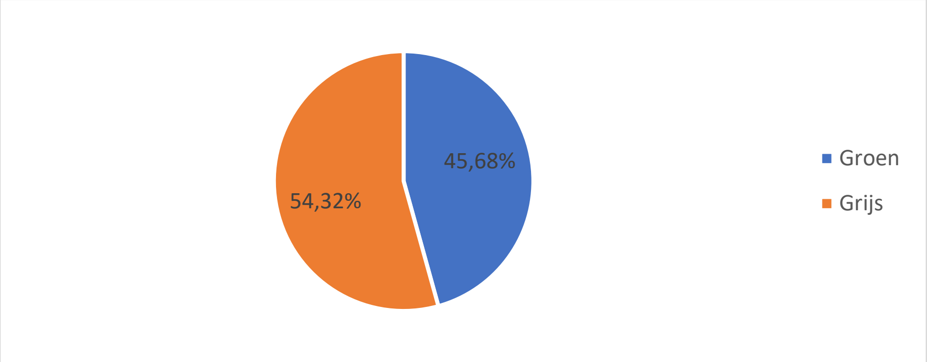


Figure 5 The percentage of ‘green’ electricity in the Business as Usual.

For individual profiles, the match does not change much from the average. The match of the KPN profile with green electricity in the BAU scenario is 44%. In this analysis is assumed that all available green electricity is equally distributed over all demand (*pro rata*).

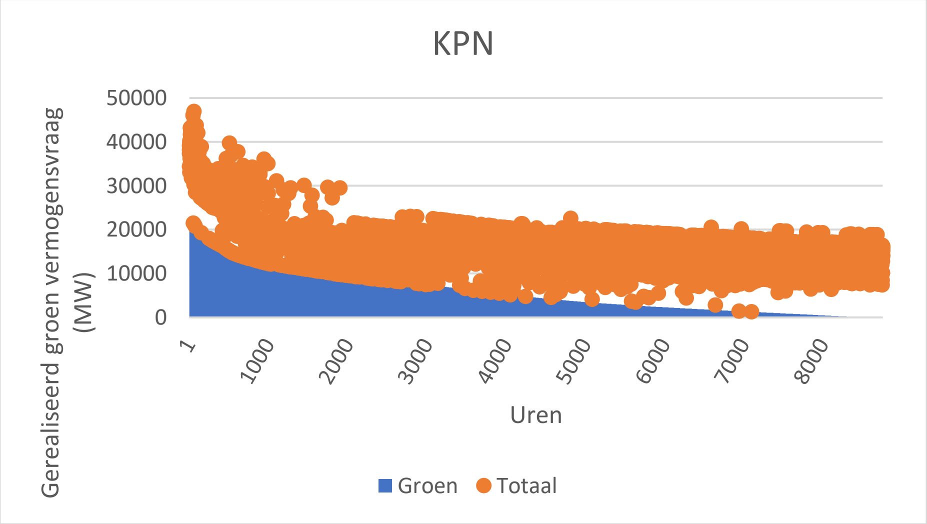


Figure 6 The match duration curve for the KPN profile. The orange dots shows the total demand in MW for the corresponding blue lines.

3.2 Experiment B - Availability of green electricity and flexibility potential

When some consumers are preferring green electricity at all price they can increase their green matching score a lot. If 10% of all consumers is preferring green electricity at all price, this group get a green matching score of 95%. Adding storage can increase this score even up to 100%. As shown in Figure 7, this score is decreasing since there are less and less hours on which all demand in the green electricity can be cleared.

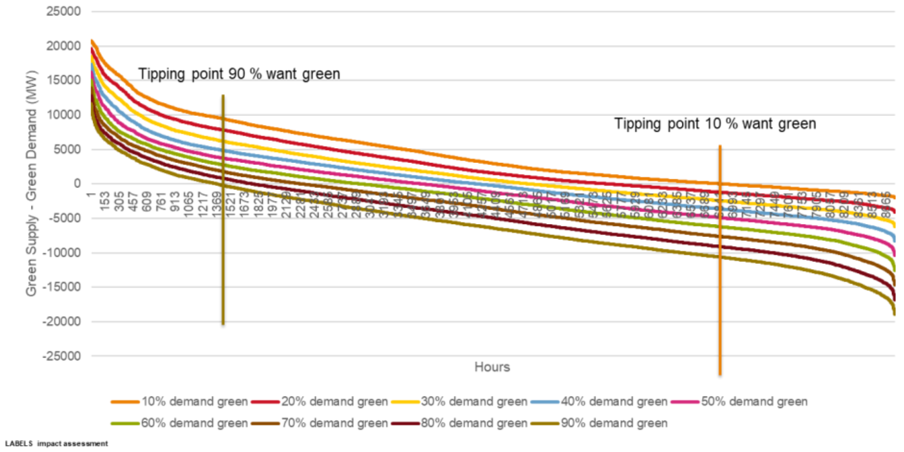


Figure 7 The surplus of green electricity given the amount of consumers that prefer green electricity. Two tipping points are visualized: the moment there is no more green electricity available.

As shown in Figure 8 the match with NLGREEN electricity for the KPN and TNO profile is a little bit above the average demand. This is a little bit different from the 2030scenario, where also the demand from flexible industrial sources were included (electrolyzers and power-to-heat). Compared to other static demand (see Table 4), KPN and TNO have a slightly better (natural) match with renewables.

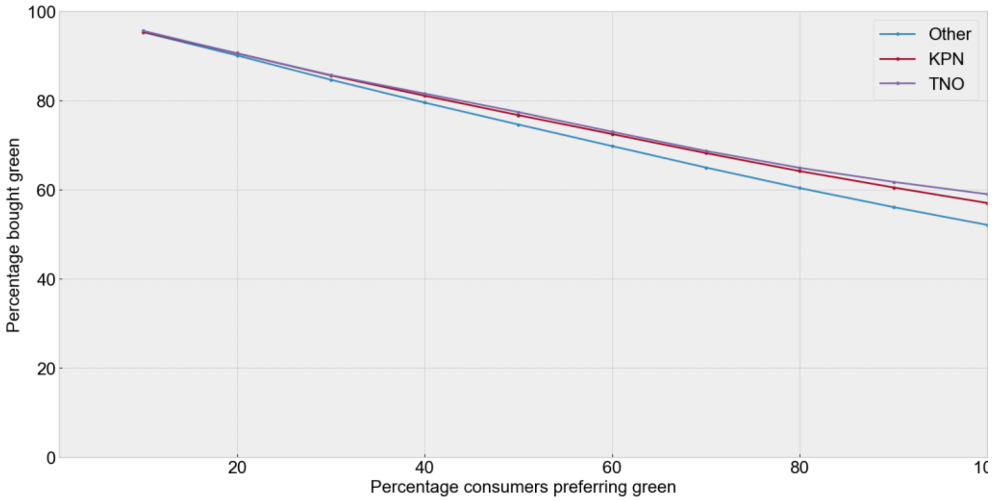


Figure 8 Percentage green electricity bought by consumers (KPN, TNO and others) when 10-100% of the consumers prefer green electricity over unlabeled electricity. Flexible demand (power-to-heat and electrolyzers) are not included in the demand.

In Experiment B the KPN batteries are added to the NLGREEN electricity market. The storage size is too small to have an effect on the matching scores, but adding the batteries provides insights in the potential of flexibility, that is discussed in 3.4.

3.3 Experiment C - Competing for green electricity

Paying more for green electricity than other consumers is an effective strategy to increase the green matching score. However, this also changes the NLGREEN matching supply score of consumers paying less as shown in Figure 9.

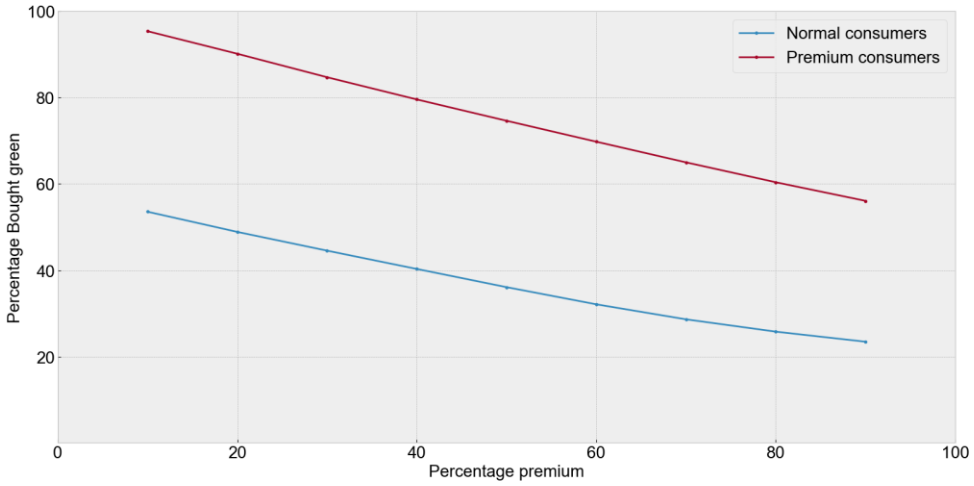


Figure 9 The green electricity matching score for normal and premium consumers.

3.4 Potential for flexibility (Experiment B)

Flexibility can be used to shift demand or supply to another moment in time using demand response or storage. When there is surplus of renewable supply demand can be shifted to these hours and storage assets can charge. When there is surplus of demand for NLGREEN electricity, consumers can reduce their demand and storage assets can discharge the renewable energy they have consumed during moments of renewable supply surplus.

This means that the potential for flexibility on the NLGREEN electricity market is limited by either the amount of renewables that was not matched with demand or the amount of demand not matched with renewables. Figure 10 shows the potential of storage and how this is limited by the surplus of demand (discharging opportunities) or the surplus of supply (charging opportunities). This is also the potential for other types of flexibility such as demand response, however the ability of e.g. demand response to use this potential is smaller.

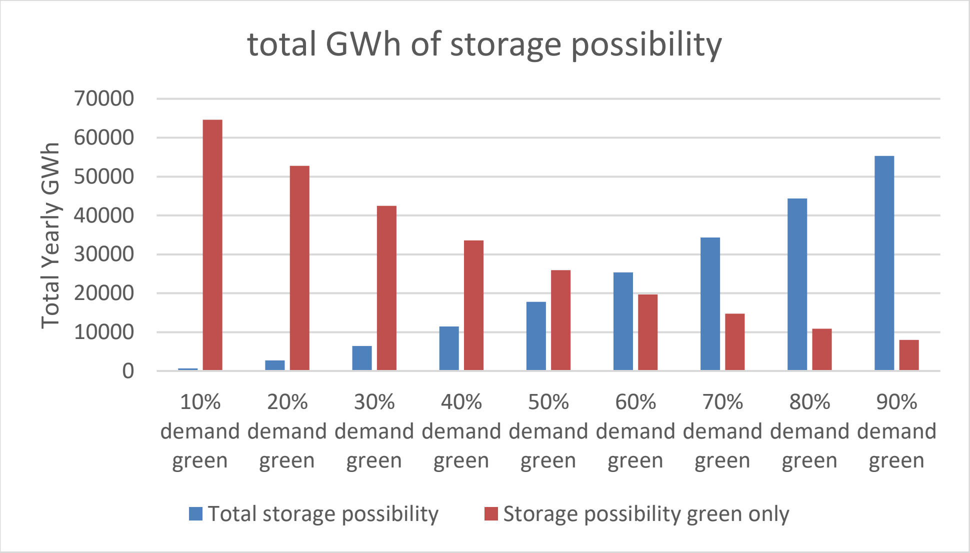


Figure 10 The storage potential for the proposition ‘delivering NLGREEN electricity’ given different amount of demand that prefers NLGREEN over unlabeled energy at a price high enough to compete with hybrid flexibility options (electrolyzers, power-to-hea) and to cover the cost of flexibility or storage.The red line shows the amount of NLGREEN electricity that is not cannot be matched without storage or flexibility. The blue line shows the amount of NLGREEN demand that cannot be matched without storage or flexibility.

In the 2030 scenario, the optimum is at 50% demand where the number of charging opportunities and discharging opportunities is equal. This ‘optimum’ is the optimum for flexibility options that can arbitrage over a window of a year. The storage potential for flexibility options with shorter arbitrage windows (demand response, storage assets with high self-discharge of longer period) is lower.

In the NLGREEN electricity market the KPN (NiMH) battery was added. Figure 11 shows that the number of operating hours of the battery depends on the amount of demand that is willing to buy green electricity at such a high price such that they are willing to buy green electricity from storage.

The number of operating hours of the battery are low, this is mainly because of the limited storage capacity. After three charging hours the battery is completely full and is not able to charge more. Typically, the number of hours of renewable surplus on the electricity market are larger than 3 hours before a surplus of green electricity demand is seen.

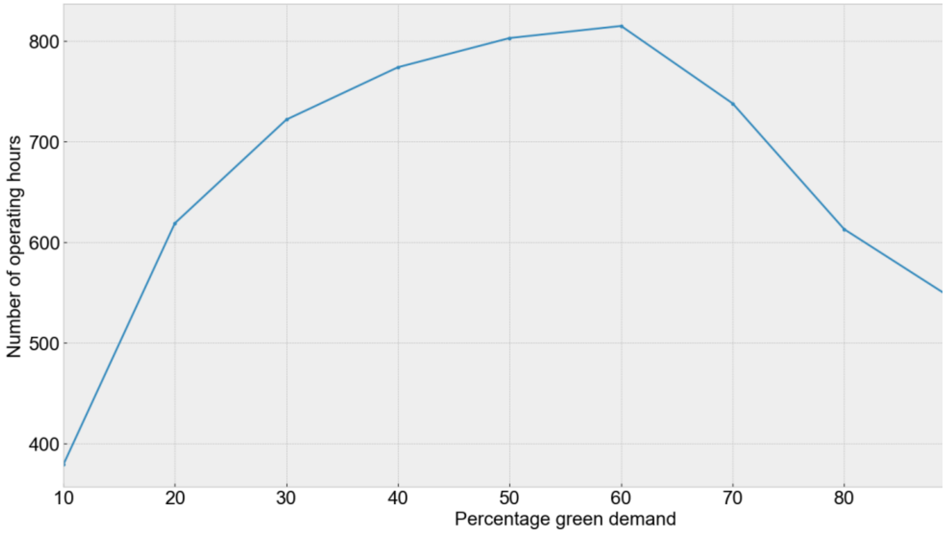


Figure 11 Number of operating hours of the KPN battery in the green electricity market for different percentages of green demand.

3.5 All about price

In all experiments we did relative assumptions about the willingness-to-pay of consumers, but what does this tell us about the real willingness-to-pay of consumers or price-to-pay for green electricity. Are consumers going to shift demand or pay for storage?

Non-flexible consumers need to pay extra for storage (or virtual storage via demand response) if they want to buy NLGREEN al over the year. Flexible assets such as electrolyzers, power-to-heat flexible demand of EV and residential heating will always be in a better position and thus buy NLGREEN for a lower price: they don’t need to pay extra for a storage or flexibility service...

This is a threat to storage providers that like to provide NLGREEN, but an opportunity for flexibility provider to deliver additional services e.g. electrolyzers can turn on for less hours than needed for a positive business case by leaving NLGREEN for non-flexible consumers at the highest price moments. From an energy system perspective having NLGREEN labeled electricity is a market-based solution for solving issues as ‘electrolyzers are going to consume all renewable energy’.

In the 2030 scenario an amount of 5 GW industrial flexible demand is simulated. Figure 12 shows that 5 GW surplus happens once in a while, but more surplus is rare. In total there is 5TWh of surplus spread over 1200 hours. The NLGREEN proposition provides an incentive to invest in flexible assets while they cannot have enough operating hours in a year otherwise. The NLGREEN proposition is thus a way to make the business case of flexibility better by letting non-flexible prosumers pay for flexibility in a transparent way.

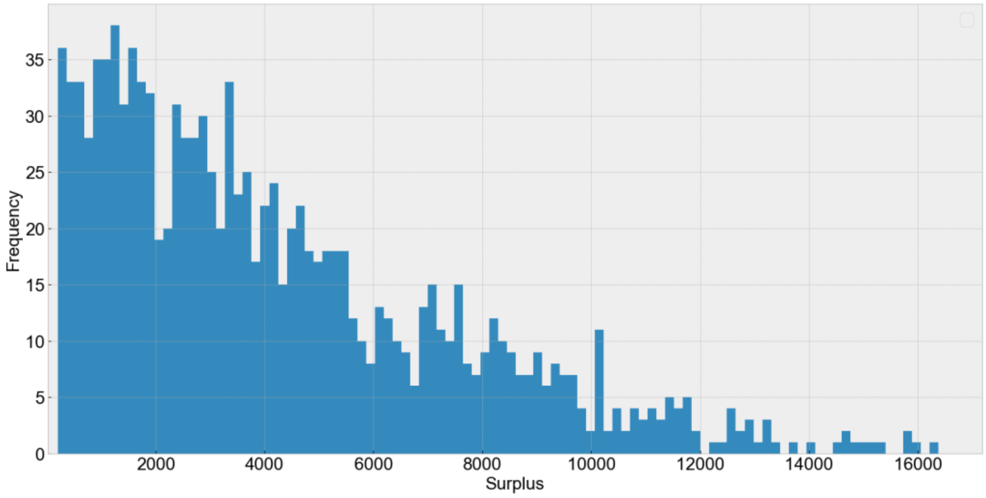


Figure 12 MW surplus of NLGREEN electricity in the green electricity market when 100% of the non-flexible demand buys green electricity (renewables, storage is not simulated in this experiment).

This said, storage propositions for NLGREEN electricity in 2030 are foreseen to be a niche market, even if the majority of consumers prefers green electricity: there is not enough electricity for all and the willingness-to-pay of non-flexible consumers is probably not high enough to overcome the costs of storage On the other hand for flexible assets as EV, residential and industrial heating and electrolyzers that have almost a positive business case the NLGREEN (consume NLGREEN only when there is not enough non-flexible demand) proposition can make the difference. This is a market-based alternative to rules or subsidy-limits on the number of operating hours of flexible assets e.g. electrolyzers, e-boilers.

4 Discussion

4.1 Impact of assumptions

The assumption mostly impacting the results of this study is the amount of installed renewables. If we install the double capacity of renewables the potential for storage grows. The number of moments with renewable surplus on the green electricity market increases from 1200 to 5400 hours (if everyone wants green electricity), which is more than the moments of green energy demand surplus (4300 hours). This effect is shown in Figure 13.

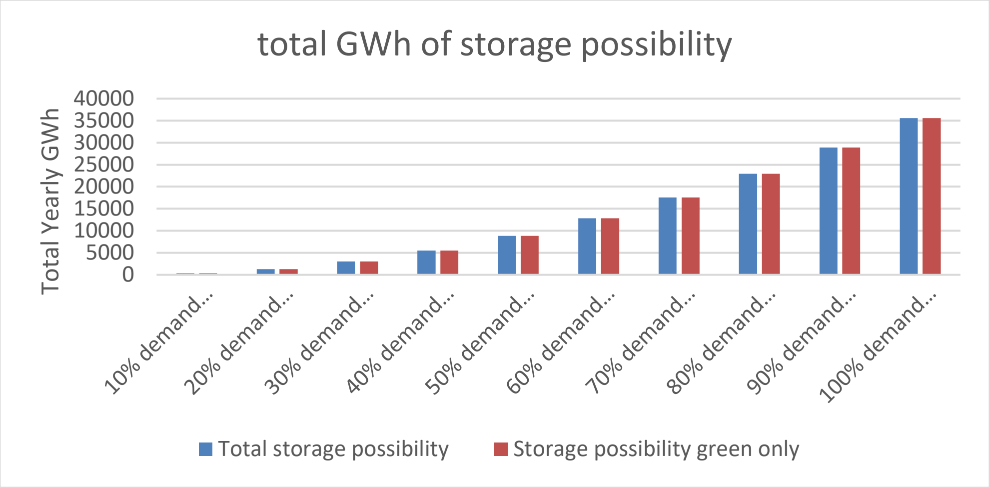


Figure 13 Storage potential for green electricity when the amount of renewable energy in the 2030 scenario has doubled.

When renewables installed are doubled, we see that the moments of excess of demand willing to pay more for green electricity is the factor defining the business case for flexibility instead of the surplus of renewables.

We also see the number of operating hours for the KPN battery growing when the percentage of green demand grows (Figure 14). It is not limited by the renewable supply anymore. However, the number of operating hours of this small battery is still small since it cannot charge for more than 3 hours before discharging.

As shown in Figure 12 , there is more need for storage at peak moments of supply surplus, but the amount of operating hours per year is small for storage assets. Storage techniques with a large storage capacity and small self-discharge over time are useful here.

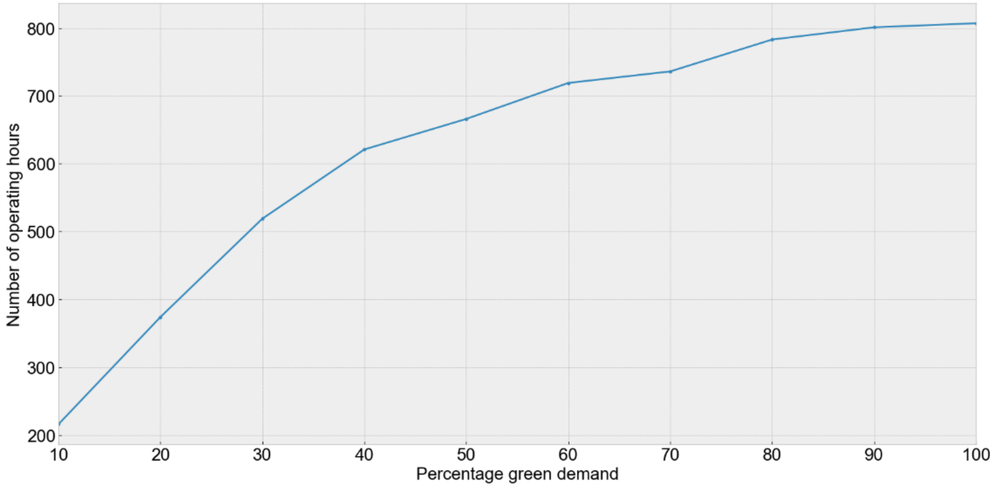
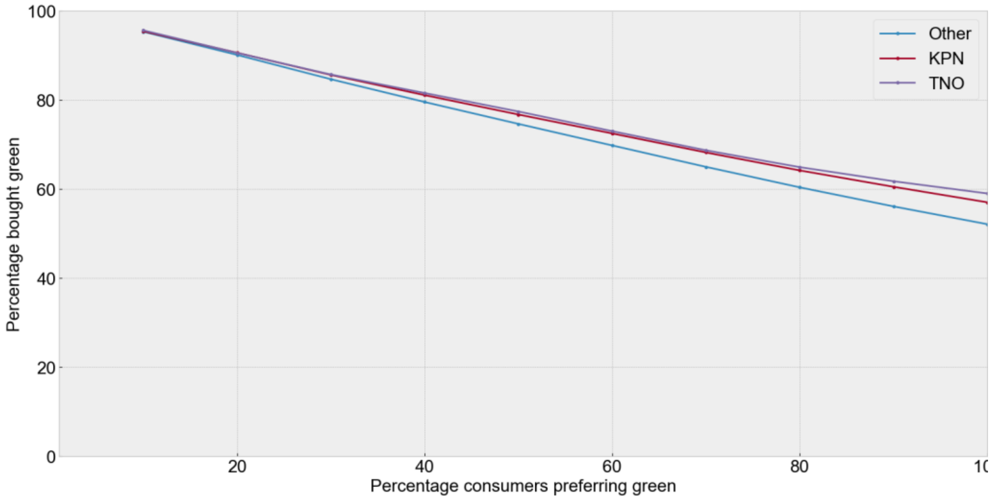


Figure 14 Number of operating hours of the KPN battery when renewables installed are doubled.

Doubling the renewables installed also changes the matching score for demand (Figure 15, compare with Figure 8).



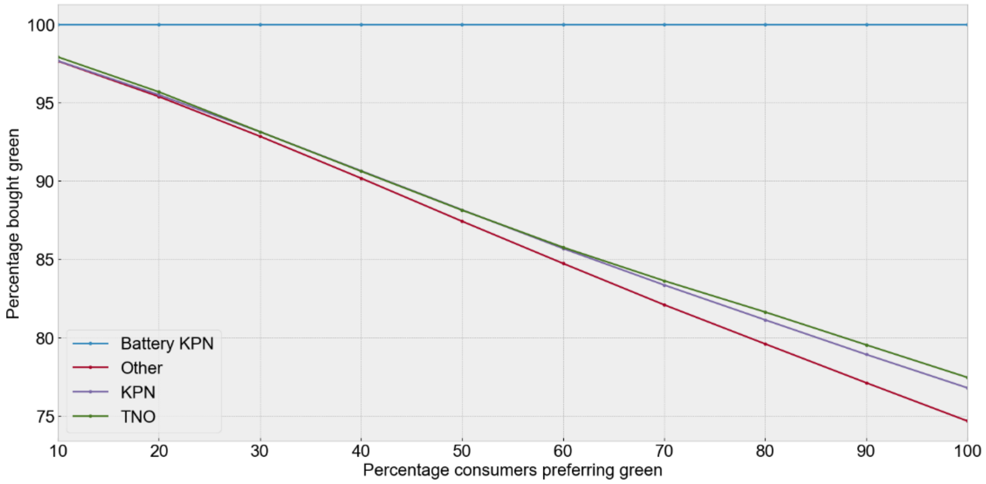


Figure 15 Percentage bought NLGREEN for KPN TNO and others when double renewables are installed.

4.2 Value stacking

Flexibility can be used for several value propositions. Value stacking increases the profits of a flexibility asset by combining services. The NLGREEN electricity value proposition can be stacked with other services, but in this study the added value is shown for a single value proposition. This NLGREEN electricity value proposition can be combined with balancing services e.g. by providing FCR or a/mFRR services to the TSO or congestion management services to the DSO.

Stacking of services is not always possible e.g. capacity reserved for FCR cannot be used to store NLGREEN electricity. However we expect that with good forecasts and optimization strategies LABELED energy propositions can be stacked with most balancing and wholesale propositions.

5 Conclusions and next steps

The main take-aways from the impact analysis of the LABEL concept using the use case ‘green electricity market’ are:

- The LABELS concept can increase the matching of renewables of individual consumers a lot. If 10% of the consumers are buying green electricity, this group will increase their matching score from 45% to 95% in the 2030 scenario. However the increase of the NLGREEN matching score of one consumer reduces the score of others as long as flexibility is not used.
- Flexibility can increase the matching score of individual consumers even more: up to 100%. However the number of hours of supply surplus are limited in the 2030 scenario. When 100% of the consumers buy green electricity, there are approx. 1200 hours of renewable surplus while there are 7500 hours of green demand surplus (in the 2030 scenario).
- Offering a LABELED energy proposition (such as ‘always NLGREEN’) as a storage provider is a niche product in 2030: there is not enough renewable surplus and it is more likely that surpluses are used by flexible assets such as electrolyzers, hybrid heating of industrial processes. If the amount of renewables doubles, there are more hours of green supply surplus than green demand surplus and also NLGREEN propositions for storage provider are interesting.
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The impact assessment focused on the impact of the LABELS concept on the NLGREEN matching score – the amount of demand that is matched with wind or solar electricity produced in the Netherlands- of consumers and the potential for flexibility. Other effects such as stimulating the investment in renewables are not evaluated. The analysis of this effect requires an additional social-economic assessment analysis that studies the willingness-to-pay of consumers for certain matching scores.