



gemeente

DEN HELDER



Future Energy Vision Den Helder

Foreword

Dear reader,

In the municipality of Den Helder we face a major challenge. Our ambition is to be energy-neutral by 2040. But what does that mean? How much energy do the built environment, the port and traffic consume? When will we have achieved our ambition? And how are we going to achieve this ambition?

The Future Energy Vision before you describes an energy mix and a number of scenarios. It is a broad exploration of the possible building blocks. Each building block has particular advantages and disadvantages. These are what we want to discuss together. Space is scarce, which means we have to make well-considered choices. That matters, because initiators of sustainable energy generation and storage are approaching the municipality. They want to make developments possible such as a small nuclear reactor, green gas production, hydrogen production, battery storage, energy from water and solar fields. Some initiatives may in the future supply electricity or heat to residents and businesses in Den Helder, but in most cases this is intended for the region, the province or even the Netherlands as a whole, as with the landfall of electricity and hydrogen from offshore wind.

It is our task to assess these initiatives not only on energy production but also on indicators such as environmental quality, the economy and employment. That is why the Future Energy Vision includes an assessment framework for measuring initiatives against a common ‘yardstick’, particularly as space will also be needed in the near future for housing, work, nature and recreation.

Kind regards,

Peter van Diepen

Alderman for Sustainability and Energy Transition, Den Helder

Summary (1/3)

Over the coming decades the municipality's local energy transition will be accompanied by far-reaching electrification in almost all sectors, but above all in the built environment, shipping (shore power) and road traffic.

The local energy system is not in balance. Without additional large-scale electricity production, demand for sustainable electricity considerably exceeds supply. This applies to both the city and the region, and to both the short term and the long term (after 2035).

The largest (future) electricity consumers are the built environment and shore power. This electricity demand cannot be met within the current frameworks of the RES, neither at local nor at regional level. Demand for (green) electricity may rise even further with large-scale local production of hydrogen (carriers).

The energy consumption – mainly liquid fossil fuels – of the ports of Den Helder (civil and military, including the airports) is comparable to the energy consumption of the city of Den Helder.

Neutrality for the city of Den Helder is not impossible, but it does require the realisation of one or more additional large-scale building blocks such as large-scale digestion, energy from water (wave energy, tidal energy) or a Small Modular Reactor (SMR). In addition, policy must also commit to small-scale sources such as solar-thermal roofs, ground-source energy and residual heat.

Neutrality for the municipality of Den Helder – the city and the ports – appears to be possible only if an SMR is realised, although it might also be achieved through functioning as an 'energy hub' combined with exclusive purchase and sales agreements for low-carbon energy. It is recommended that talks be opened with the authorities on the conditions governing the attribution of low-carbon and renewable energy to Den Helder.

Summary (2/3)

Part of the Future Energy Vision is the Den Helder Energy Transition assessment framework, with building blocks and indicators as its elements. Building blocks are large-scale (> 2 ha) energy technologies that contribute as much as possible to the municipality's objective of being energy-neutral by 2040. Examples of indicators are the contribution to energy supply and the economy, the effect on the living environment, and the pace and certainty with which developments can take place.

The framework shows how the various building blocks perform against the indicators, as an aid for weighing up interests with regard to certain strategic choices in the energy transition.

	Bouwstenen									
Indicatoren	Batterijopslag	Warmtenet	Zonnevelden	Grootschalige vergisting	Golfenergie	H ₂ -productie via E (H2G)	SMR	Aanlanding E	Aanlanding H ₂	H ₂ -productie via G (H2B)
										
Energie / CO ₂				+	+		++	++	+	+
Economie	-	-	-			+	++	+		++
Leefomgeving		+	-	-	+		-	--		-
Urgent / Robuust	+	+			-		-	-	-	

Afwegingskader Energietransitie Den Helder met indicatoren en bouwstenen op hoofdlijnen. Een blanco veld impliceert een neutrale score.

Summary (3/3)

The municipal council was asked, by means of a written survey, about its preferences for indicators with regard to how the energy transition should be shaped. It emerges that indicators such as support among the residents and businesses of Den Helder and limiting land take and emissions carry more weight than sufficient local renewable energy production. Attention to nature and landscape development and economic aspects such as employment, investment and knowledge development carry roughly equal weight. There appears to be a slight preference for locally produced energy benefiting Den Helder rather than being supplied to third parties. Finally, the import of low-carbon energy is also seen as an acceptable transition pathway for Den Helder.

This implies a preference for small-scale sources supplemented by large-scale building blocks that require relatively little space, such as battery storage, heat networks, energy from water and the landfall of hydrogen. For technologies that require a great deal of space, such as ground-mounted solar, support appears to be limited. Building blocks such as the Small Modular Reactor (SMR), large-scale digestion and hydrogen production sit in the middle. These building blocks have both advantages and disadvantages, and opinions on their applicability for the municipality are divided.

In order to determine the bandwidth of the energy transition, four transition pathways (scenarios) have been drawn up. These differ mainly in terms of building blocks, energy production and use of space. The scenario that appears to fit best with the council's positions is the 'Focus on the living environment' scenario. However, this scenario does not lead to energy or climate neutrality, nor does it deliver results in the short term.

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Purpose of the Future Energy Vision

The purpose of the Future Energy Vision is to have the council adopt indicators and building blocks as the elements of the energy transition assessment framework.

Examples of indicators are the contribution to employment, the contribution to energy supply and the realisation timeframe. Building blocks are large-scale (> 2 ha) energy technologies that contribute as much as possible to the municipality's objective of being energy-neutral by 2040. Examples of building blocks are a heat network, battery storage, solar fields, large-scale digestion, energy from water (mainly wave energy), large-scale deployment of (bound) hydrogen and nuclear energy (SMR).

Prioritising indicators provides insight into the consequences of choosing particular building blocks. On that basis the municipality can make a well-considered decision, for example to:

- Impose preconditions on large-scale energy projects
- Designate locations where certain developments may take place
- Support certain developments, for instance with subsidies, subsidy applications or by facilitating infrastructure.

The municipal Future Energy Vision stems from various international and national policy agreements such as the Paris Climate Agreement, the national Climate Agreement, the Regional Energy Strategy (RES), the provincial Energy Vision and the provincial Multi-year Programme for Energy and Climate Infrastructure (pMIEK).

State of the local Energy Transition (1/3)

Den Helder has relatively high energy consumption. There are several reasons for this, including a poorly insulated housing stock, limited multi-storey housing, no industrial residual heat, inland shipping, TESO and high energy consumption on the various business parks, including Kooypunt and Oostoever.

Progress on the energy transition is limited. Energy consumption has admittedly fallen sharply over the past fifteen years, but this is attributable to a declining population and a shrinking economy. This trend is not expected to continue. The relative contribution of sustainable energy in 2024 is around 10%, mainly solar power and the (mandatory) use of biofuels in road traffic. Unlike other municipalities, there is little or no contribution from biogas, aquifer thermal energy storage and ambient energy such as air-source heat pumps. Because of height restrictions resulting from the airport and radar, large-scale wind energy is not an option.

The municipality of Den Helder is therefore not yet on the desired transition pathway towards neutrality in 2040.

That said, an above-average amount of solar has already been realised, both on roofs and ground-mounted, and a large solar park near the airport is still under construction. Finally, a number of (premature) initiatives are under development at Kooypunt/Kooyhaven, including a digestion plant, an SMR, hydrogen production, methanol production and electricity storage, with the caveat that an SMR is not currently an option within the RES.

It should additionally be noted that, on the basis of current analyses, neutrality appears more achievable than in the past. Future energy consumption is estimated to be lower, and the renewable energy potential is estimated to be higher, than before 2020. Moreover, there is a structural decline in CO₂ emissions.

State of the local Energy Transition (2/3)

Current consumption by source/technology

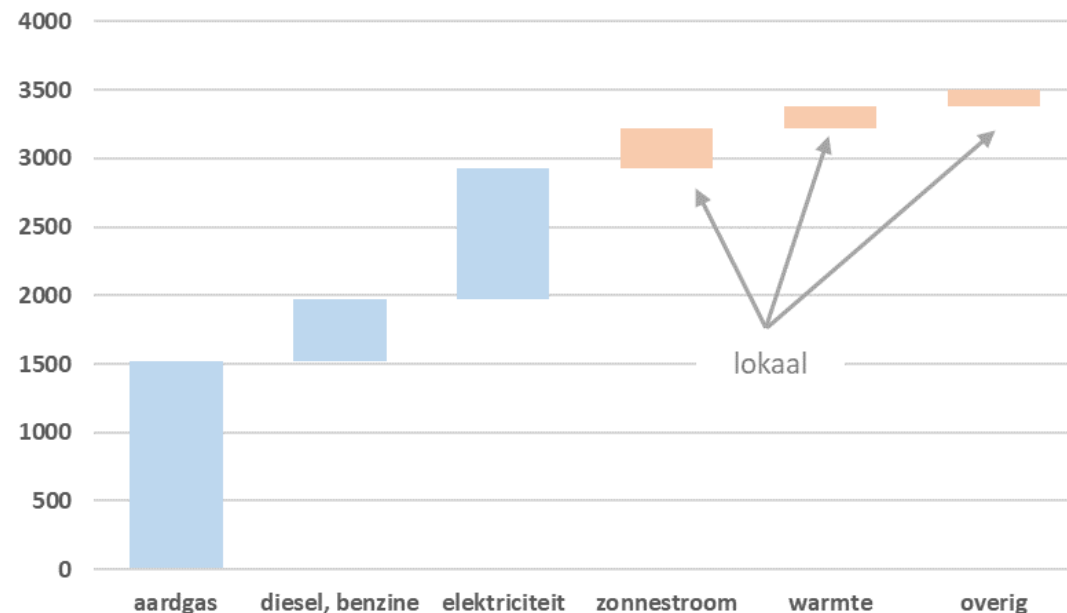


Figure 1: Composition of the energy consumption of the city of Den Helder in terajoules (TJ), excluding bunker fuels. Current consumption is approximately 3,500 TJ, of which around 10% (solar power, heat and other) is largely produced locally. The remainder (natural gas, electricity other than solar or wind, diesel and petrol) is produced or extracted elsewhere.

heat (warmte) = including residual heat, ambient heat and woody biomass.

other (overig) = including biogas, green gas, bio-transport fuels, hydrogen and wind energy.

3,600 TJ = 1 TWh

Source: Klimaatmonitor and own analysis.

State of the local Energy Transition (3/3)

Current consumption by sector

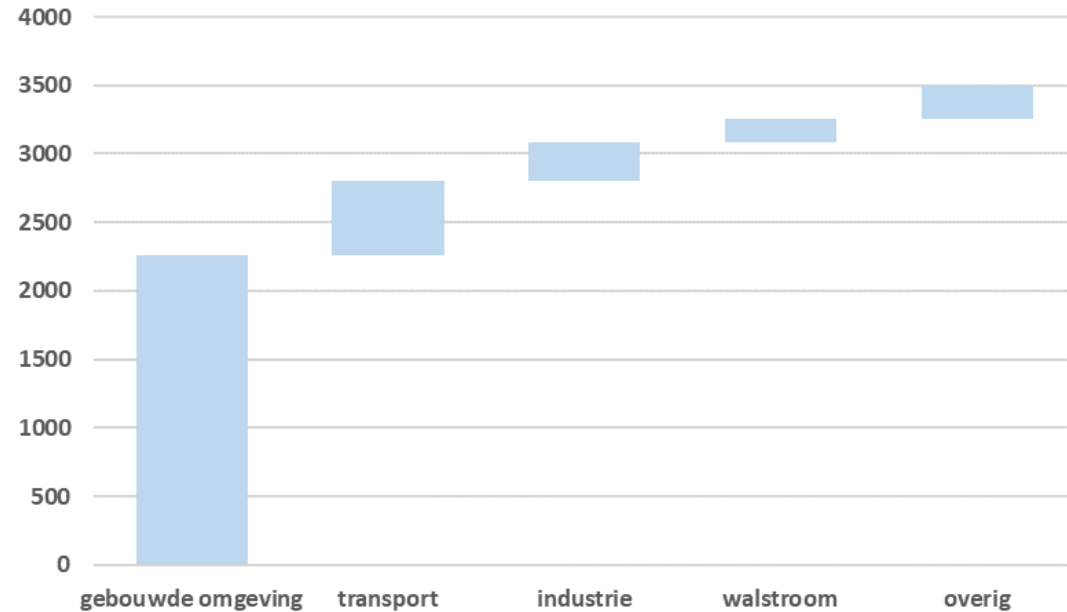


Figure 2: Composition of the energy consumption of the city of Den Helder in terajoules (TJ), excluding bunker fuels, broken down into the sectors built environment (gebouwde omgeving), transport, industry (industrie), shore power (walstroom) and other (overig, including agriculture).

3,600 TJ = 1 TWh

Source: Klimaatmonitor and own analysis.

Local Energy Transition: Heat sector

There are (as yet) no large-scale heat networks in the municipality, and heat demand is met mainly by gas boilers. A gas-fired combined heat and power plant of the Ministry of Defence, connected to a local network, will be decommissioned in due course.

It is known, however, that deep geothermal energy has potential in Noord-Holland. Geothermal heat is therefore expected to be the largest source for future collective heat supplies. Nijverheidsweg in Den Helder has been designated as the location for a geothermal well. Possible supplementary sources for heat networks are electric peak boilers and – if available on a large scale – residual heat, solar heat and aquifer thermal energy storage. It is expected that 15–20% of heat demand can be met collectively and sustainably in this way in future.

The remainder can be met with (hybrid) heat pumps and green gas. A national proposal is being prepared to make the use of a hybrid heat pump in the built environment mandatory from a certain date. By 2030, 10–15% of gas demand in the built environment must also consist of green gas. Green gas can make buildings and neighbourhoods more sustainable where there are no alternatives, such as listed buildings. Although there is much debate about the availability of green gas, such a contribution is not unrealistic. Finally, a further part can be met with – if deployed on a small scale – residual heat, solar heat and aquifer thermal energy storage.

All in all, it is possible to make heat demand largely sustainable over the coming decades. It should be noted, however, that the production of heat and green gas also requires a great deal of electricity. The heat sector is therefore, in a sense, being electrified.

Local Energy Transition: Transport sector

Around 25% of energy consumption is within the transport sector, which is neither particularly high nor low compared with other municipalities. The absence of motorways and heavy rail traffic is offset by energy-intensive inland shipping, the TESO ferry service and the presence of a port and an airport.

Light traffic

It is to be expected that most fossil-fuelled passenger cars, taxis, motorcycles, vans and the like will switch to electric drive in due course. TESO has already announced that it will switch to electricity in due course.

Heavy traffic

The transition pathway for heavy (long-distance) freight traffic, buses, tractors and so on is still open – biofuels, hydrogen, LNG and electric drive, among others, are options. The share of heavy traffic in the municipality is limited, although some demand is expected near logistics hubs (including Vepa Bins, Kooypunt).

This means that local transport will be (and must be) extensively electrified.

Local Energy Transition: Electricity sector

A great deal of solar has already been realised within the municipal boundaries, both on roofs and ground-mounted. Around 2030, solar and small-scale wind turbines can generate well over 0.1 TWh per year.

For many municipalities, depending on the scenario, the contribution of solar is expected to double or triple again after 2030. Because a relatively large amount of solar capacity has already been installed in Den Helder, space within the municipal boundaries of Den Helder is limited and the council is hesitant towards new large solar fields, we conservatively assume around 0.2 TWh.

Future local demand for green electricity, by contrast, exceeds 0.6 TWh. Moreover, the contribution of solar in the winter months is negligible, and in the other months it is limited to daytime unless heavy investment is made in (long-duration) storage of solar power in home batteries or neighbourhood batteries.

For the short and medium term, however, no other sources for the production of renewable electricity have been identified within the current frameworks of the RES (only solar & wind count towards the bid).

This means that, in the normal course of events, the municipality of Den Helder will have to draw electricity extensively from the region, the North Sea or the Netherlands as a whole.

State of the regional Energy Transition

For historical and geographical reasons, the municipalities of Texel, Den Helder, Schagen and Hollands Kroon cooperate on various themes at a regional level, in the so-called Kop van Noord-Holland.

Energy consumption in the Kop van Noord-Holland amounts to around 1% of the Netherlands and, apart from the built environment, is dominated by the ports and the 'Agriport A7' business park near Middenmeer, in particular greenhouse horticulture and the data centres.

Within the RES framework, a regional contribution of 2.3 TWh to the Noord-Holland Noord bid has been laid down. The overall bid of the NHN region is 3.6 TWh.

The largest contribution to both bids is provided by the already realised 'Windpark Wieringermeer' near Middenmeer in the municipality of Hollands Kroon. This wind farm also results in a high percentage of sustainable energy. At regional level, the Kop van Noord-Holland, around 20–25% of energy demand is already met sustainably.

Regional Energy Transition: Heat sector

Apart from the heat demand of the built environment, where transitions similar to those for the municipality of Den Helder are expected, there is very substantial demand from greenhouse horticulture.

The future of greenhouse horticulture is uncertain. In this vision we assume that the sector is largely retained and is made sustainable by means of various technologies. Likewise, the combined heat and power capacity associated with greenhouse horticulture remains in place, although the number of full-load hours will steadily decline.

Sustainable technologies that will be applied in greenhouse horticulture include geothermal heat, heat pumps, biomass, residual heat, solar heat, heat storage and hydrogen. Making combined heat and power (CHP) sustainable by means of hydrogen is, however, less obvious, because electricity is precisely what is needed to produce hydrogen. The future of hydrogen-fuelled CHP is therefore uncertain (TenneT, 2024).

Unlike other sub-markets, direct electrification is not expected to play a major role in making the greenhouses sustainable. The increasing demand for electricity stems mainly from the electricity consumed in generating the heat (circulation pumps, heat pumps and the like).

Regional Energy Transition: Transport sector

The bunkering facilities in Den Helder, including the airport, consume around 3.7 PJ (100 million litres) per year, which is roughly as much as all other sectors in the municipality combined (Total, 2024). This is moreover exclusive of electricity consumption in the ports and the airport, such as that of property, outdoor lighting, shore power (mandatory from 2030) and the like.

As with greenhouse horticulture, it is uncertain what the future of the port complex and its future energy supply will look like. Fully electric propulsion with batteries is not a logical choice for many vessels. Alternatives are HVO diesel, hydrogen, liquid hydrogen and methanol. Hybrid propulsion (partly electric, partly otherwise) is also a realistic option. For safety reasons, ammonia is not seen as an option locally.

A number of projects are under development to make this possible, such as 'Zephyros' at Oostoever (Kooyhaven).

In addition, the shipping sector is investing heavily in energy saving. From 2025, all new sea-going vessels must be built to be at least 30% more energy-efficient than in 2014. Furthermore, the European Commission has proposed for shipping that the annual greenhouse gas intensity of the energy used on board be reduced by 75% by 2050. With the same number of ship movements, this could in time lead to a decline in consumption at the bunkering facilities in the port(s).

If synthetic fuels gain the upper hand in the sustainability transition and these are produced via electrolysis and synthesis, around 250 megawatts (at 7000 hours and 50–70% yield) of additional (renewable) electrical capacity will be required. Because an (unknown) share of shipping will in future be hybrid or fully electric, this capacity may turn out lower.

Regional Energy Transition: Electricity sector

Within the RES, the region has the ambition of generating 2.3 TWh sustainably per year by 2030. According to Statistics Netherlands (CBS), 1.9 TWh had been realised by the end of 2022. As only 0.4 TWh remains to be realised over the next eight years, this ambition does not appear unachievable despite grid congestion, with the caveat that failure to meet the bid may lead to a 'designation order' (*aanwijzingsbesluit*) from the Province.

Against this, however, the data centre cluster in Middenmeer consumes around 2.5 TWh. The current RES ambition is therefore insufficient for the electricity demand in the region. Consequently, Den Helder cannot make use of a regional surplus either.

After 2030 the RES could be scaled up, but within the current frameworks this would entail a substantial expansion of onshore wind. It is questionable whether there is support for this. Several alternatives have already been mentioned, such as an SMR, large-scale solar-on-water, imports and large-scale hydropower (tidal, osmosis and wave energy).

In the coming period, discussions will begin between central government, the decentralised authorities and the regions on the outlines of the RES task after 2030. Any RES target for 2040 is expected to be considerably higher than that for 2030 (NPE, 2024).

Building blocks for the Energy Transition (1/2)

In order for the municipality of Den Helder to become as self-sufficient in energy as possible, seven large-scale technologies (> 2 ha) have been identified, in increasing order of scale:

1. **Battery storage**
2. **Heat network**
3. **Solar power**
4. **Large-scale digestion**
5. **Wave energy**
6. **SMR**
7. **Energy hub**

The first and the last building blocks are different in nature. Battery storage involves no energy production, while the last implies that the municipality does not, strictly speaking, necessarily become energy-neutral, but does take up a position as a large-scale production and distribution location ('hub function') for renewable and low-carbon energy. This is the case, for example, if natural gas or wind energy is imported on a large scale from the North Sea. In fact this transcends the municipality and the region, but it has been included for the sake of completeness.

The main technologies listed above are implicitly supplemented by (partly) autonomous developments of small-scale sources such as geothermal heat, solar heat (on roofs), residual heat, small-scale wind turbines and aquifer thermal energy storage.

Building blocks for the Energy Transition (2/2)

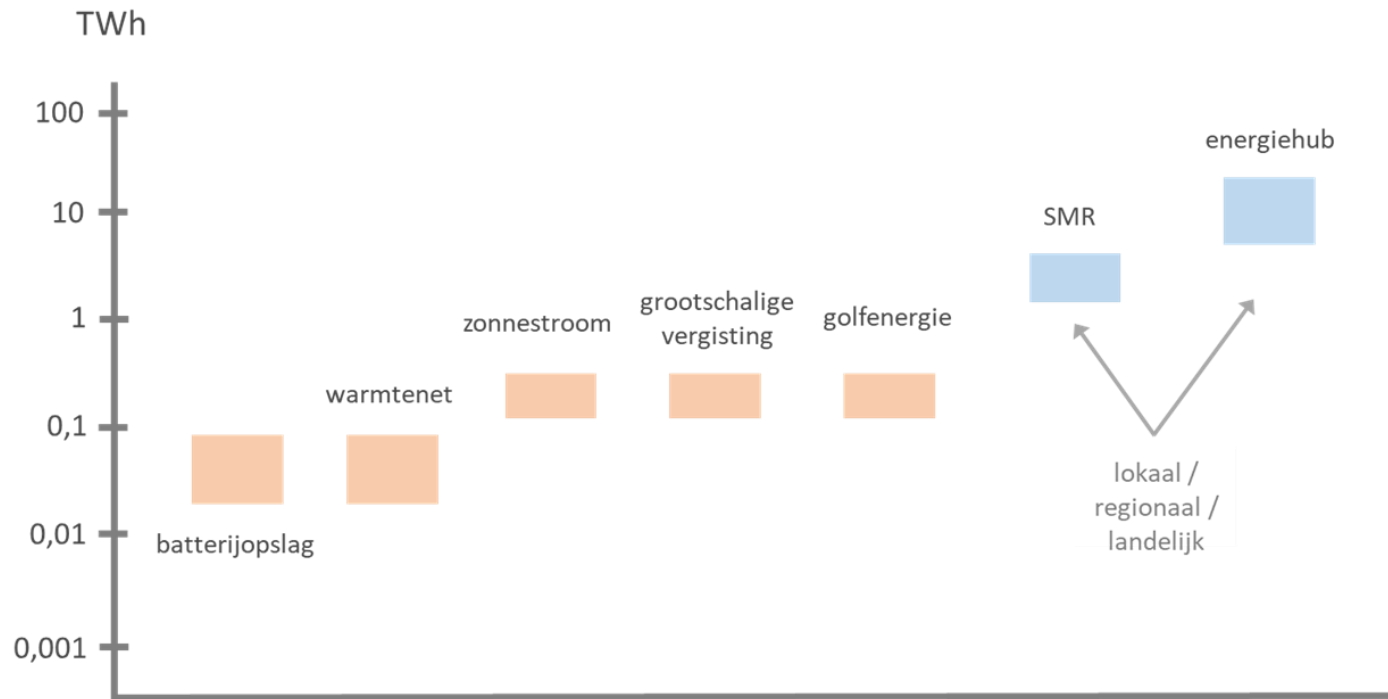


Figure 3: Indicative future annual contribution of the various building blocks to the energy transition in Den Helder in terawatt-hours (TWh). Note the logarithmic scale.

For comparison: the baseline energy demand in Den Helder is around 1 terawatt-hour per year, excluding bunker fuels (see also Figures 1 & 2). Solar power, digestion and energy from water (wave energy) could in theory each meet around 20% of the city's baseline energy supply. The SMR and the Energy hub, by contrast, are supra-municipal in character.

1 TWh = 3,600 TJ

Building block: battery storage



In and around Den Helder there are currently at least three initiatives for the realisation of large-scale battery storage. These concern 50 megawatt batteries on the Kooypunt business park, near Julianadorp and one on the port site. In addition, there are several initiatives on a smaller scale. Batteries can be deployed in various ways: to reduce grid load, to lower electricity costs, particularly at peak moments, and to store electricity surpluses from solar & wind. Finally, a battery can also be an alternative to a grid connection.

Characteristics

- A 50 megawatt battery can store 0.0001 TWh (0.1 GWh) for 2 hours. Per year this amounts to more than 0.03 TWh. The impact in terms of TWh is relatively limited, but in terms of capacity relatively large.
- Electricity storage leads to little or no additional direct employment; indirectly it may do so via a slightly improved business climate
- Storage can be realised from 2025
- The land required for a single 50 megawatt battery is limited to around 1–2 ha
- The municipality can decide independently on storage, but has no say over the connection to the electricity grid.

Other considerations

- TenneT and the Province have indicated that, for the Den Helder location, storage for the purpose of preventing or reducing grid congestion at high-voltage (system) level is not useful
- Storage at high-voltage level may, however, be relevant in combination with the landfall of offshore wind
- Nor is there a need at high-voltage level for ancillary services such as frequency regulation
- For medium voltage (district level, business parks, ports), the usefulness and necessity of battery storage is a local consideration that requires a tailored approach
- For low voltage, storage is not a large-scale technology and is therefore not applicable to the framework / not part of this Energy Vision.

Building block: large-scale heat network



In 2021 the Heat Transition Vision was adopted by the municipal council of Den Helder. On the basis of the transition vision, it was decided to investigate the possibilities for (an extension of) the heat network in more detail.

In 2022 a declaration of intent for the heat network in the 'De Schooten' district was signed by the municipality, HVC, the Ministry of Defence, Woningstichting Den Helder and Willemsoord BV. HVC has been awarded a Heat Networks Investment Subsidy (WIS) for this heat network.

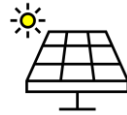
Characteristics

- The size of the heat network is uncertain, but at present 70–80 TJ of residual heat is available. Extension towards De Schooten implies a doubling of the heat supply to well over 150 TJ. In future this could increase further, for example if residual heat from electrolysis or the SMR were to become available.
- A heat network leads to little or no additional direct or indirect employment, except during construction
- Extension of the heat network can take place from 2025
- The land required is largely limited to the subsurface and the space for the sources (2 ha)
- The municipality can take decisions on the construction of heat networks in consultation with the stakeholders.

Other considerations

- There is uncertainty about the future of the Ministry of Defence's gas-fired CHP plant as a source for the heat network, and the potential of geothermal heat in Den Helder is also uncertain (ThermoGIS, 2024)
- The council has previously indicated that the 'bill' for district heating must not be passed on to residents.
- The Collective Heat Supply Act (Wet collectieve warmtevoorziening) has been postponed several times, now to no earlier than 1 January 2025. This also affects municipal decision-making on the heat network.
- Depending on the source, a heat network can partly mitigate an increase in grid congestion.

Building block: solar power



Solar refers primarily to solar fields (> 2 ha), but also to rooftop solar, solar above car parks, solar along roads, solar façades and the like, but excluding solar-on-water. Solar has been included as a separate building block because a great deal of solar has already been realised in Den Helder and the installed capacity is expected to continue to grow, albeit at a slower pace and then mainly via rooftop solar and, after 2030, also via solar panels on façades.

Characteristics

- Solar is not labour-intensive and is largely limited to the maintenance of the panels
- Solar has a limited economic impact for the municipality and the region
- The realisation of solar power is already under way and some markets are already virtually saturated
- The land required for ground-mounted solar is around 70 ha (largely already taken up)
- Decision-making lies in principle with the municipality, with the exception of the grid connection (medium/high voltage).

Other considerations

- National policy is that, barring a few exceptions, no further ground-mounted solar parks may be built on agricultural land.
- Solar is currently facing difficult market conditions, including the loss or reduction of subsidies, restrictions on feeding into the grid as a result of grid congestion, and the fact that much 'low-hanging fruit' has already been harvested in the Netherlands.
- Permits for solar parks have been granted for a period of 25 years. If the panels are not replaced by then, the contribution of solar in future may also fall rather than rise.

Building block: large-scale digestion (1/2)



A 450 kton digestion plant such as Arch Green can produce up to 700 TJ (20 million cubic metres) per year. By adding (green) hydrogen in or outside the reactor, this can be increased to well over 900 TJ.

After 2025, suppliers will be subject to a blending obligation for green gas amounting to 10–15% of gas consumption in the built environment in 2030. The aforementioned digestion plant produces, in principle, a quantity of green gas equivalent to the consumption of around 15,000 households. Green gas can above all make buildings and neighbourhoods sustainable where there are no alternatives, such as listed buildings.

With large-scale digestion, the municipality (region) can easily meet the blending obligation, and digestion can also make a significant contribution to an energy-neutral municipality.

The organic residual streams required come partly from the region, and the digestate ('organic fertiliser') will likewise be supplied as far as possible to the region's farmers (livestock farming, bulb growing, et cetera).

In addition to the use of green gas in the built environment, it could also be used in liquid form for heavy road transport or shipping. Furthermore, the renewable CO₂ released can be captured and, supplemented with green hydrogen, used as a building block for the production of other bio-based feedstocks such as bio-methanol. The Royal Netherlands Navy intends to use bio-methanol in the near future.

Building block: large-scale digestion (2/2)



Characteristics

- The number of permanent jobs is limited to 10–15, supplemented by a large number of jobs during construction
- A digester has a limited economic impact and will do little or nothing to improve the business climate (which is focused mainly on metalworking and offshore). On the other hand, fertilisation using the digestate can bring a certain benefit to the agricultural sector and indirectly preserve employment.
- Realisation of a large-scale digester is possible from 2028
- The land required is around 8 ha
- The Province is the competent authority for the environmental permit, and the project depends on the blending obligation.

Other considerations

- A digester fits within the current Kooypunt/Kooyhaven zoning plan
- Green gas likewise fits within the existing gas infrastructure
- The digestate (for bulb growing, among others) can replace artificial fertiliser and contribute to closing local cycles
- A digester plus post-treatment can also produce bio-methanol for the port (relatively cheaply).
- However, adding hydrogen to the reactor, for example at times of low electricity prices, requires an additional investment in electrolysis and the associated transport capacity. Methanol production also requires additional investment and land take.
- There is a risk of using bio-based feedstocks that have a higher-value alternative application. This can be partly prevented through permit conditions, adequate supervision and enforcement.
- The use of biogas does not prevent a shortage of local and regional sustainable electricity production from arising
- The N9 provincial road may be a constraint on the transport of manure and other organic materials.

Building block: energy from water



Energy generation from or on water has great potential. Options are tidal energy, osmosis, wave energy and solar-on-water. The feasibility of large-scale solar-on-water south of the Afsluitdijk is currently being investigated (Arcadis, 2024). Owing to opposition from Milieudefensie (Friends of the Earth Netherlands) and the Ministry of Defence, and because Den Helder is not a stakeholder, this initiative is not included in the vision for the time being. Other developments such as Symphony Wave Power are comparable in terms of energy output but not yet sufficiently developed in terms of TRL. The assumption in this vision is that more than 70 megawatts of offshore energy (including SWP, Slow Mill, Equinox) will be available specifically for Den Helder around 2035.

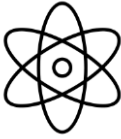
Characteristics

- No land take, but a claim on inland and coastal waters
- No or limited structural employment
- Water as an energy source fits well with an economy focused on offshore and metalworking. However, the maintenance of such systems is very limited and the solar panels will probably be imported
- Large-scale energy from water will not develop before 2035 (EU SCORES, 2024)
- The municipality has limited influence over permitting for offshore projects, as well as over the landfall.

Other considerations

- Energy from water, such as solar-on-water, is not included in the current RES bid
- Little is known about the (long-term) ecological effects of energy from water. Nature organisations are sceptical, especially near the coast. Most waters around Den Helder have Natura 2000 status and some areas are Ministry of Defence training grounds ('unsafe zone').
- The consequences of brackish or salt water for service life are equally unknown, certainly for solar panels.
- For large-scale solar-on-water, the current solar power capacity already produces sharp peaks in electricity supply, precisely at times when demand is low. Adding more solar reinforces this effect unless electricity is converted on site into other energy carriers.
- Technologies such as tidal energy, osmosis and wave energy are struggling to get off the ground (internationally too).

Building block: SMR



A 300 megawatt SMR supplies well over 2.1 TWh of electricity per year, plus optionally a comparable quantity of heat. An SMR, certainly in combination with solar, can generate more than enough energy for the municipality – and possibly even the region – to become energy-neutral.

Characteristics

- The land required depends on the capacity and the type of cooling: 10 to 15 ha, of which 1–2 ha for the ‘power block’. Part of the construction is realised underground.
- Around 60 direct permanent jobs and a large number of temporary jobs during construction
- An SMR can improve the business climate, especially for companies and organisations in the nuclear sector. A regional Pallas–SMR technology cluster could be envisaged.
- Realisation of an SMR not before 2033, but probably later (Kamerbrief SMR, 2024)
- Up to 500 megawatts of capacity, the municipality is the competent authority, although a licence from the ANVS is also required.

Other considerations

- Strictly speaking, nuclear energy is not renewable.
- Large-scale electrical infrastructure for the grid connection is lacking, although an (additional) 150 kV connection would in principle suffice; (part of) the electricity could also be sold locally or regionally via a direct line.
- An SMR does not fit within the current zoning plan, and additional land would moreover have to be acquired, for example near Kooypunt/Kooyhaven.
- A third uncertainty is public and business support, also in relation to safety.
- Using residual heat for heat networks competes with sources such as geothermal heat.
- The construction time for modern nuclear power plants in the Western world is several decades, with the caveat that these are generally considerably larger in capacity than an SMR.

Building block: Energy hub (1/2)

The final route is one in which the municipality does not, strictly speaking, become energy-neutral, but does take up a position as a production and distribution location for renewable and low-carbon energy.

Three import options are conceivable for this scenario, distinguishing between (economic) value creation via downstream hydrogen production (1 & 2) and limited value creation (3):

1. Natural gas extracted elsewhere is used on site for large-scale hydrogen production, so-called blue hydrogen (i.e. H2Gateway, H2B). This route fits well with the gas treatment facilities and gas infrastructure already present in Den Helder.
2. Electricity is imported on a large scale via the electricity network and then used for the local production of green hydrogen (H2G). This can subsequently be used within the municipality for the production of end products such as synthetic fuels, or used elsewhere after transport. Although it is in principle possible to generate the electricity required for electrolysis locally or regionally, for example by means of an SMR, in that case the electricity is withdrawn from other markets.
3. (Renewable) hydrogen is imported as a final product, for example from large-scale electrolysis in the North Sea.

There is already a concrete initiative to produce green hydrogen on a large scale, with a small electrolyser as the first phase ('Zephyros'). A hydrogen filling station at Kooyhaven is part of this project.

Combinations of import options and processing are equally conceivable, and it is also foreseeable that, in addition to large-scale hydrogen production, small-scale hydrogen production will in future take place at a number of locations in the municipality (for example at filling stations or near storage). This is also the case in the baseline scenario.

Building block: Energy hub (2/2)

Characteristics

- Imports generally involve a limited claim on land, although the landfall of electricity on a gigawatt scale requires more than 25 ha of land (Rebel, 2023)
- Employment could amount to several dozen or even several hundred jobs
- The economic importance for the municipality is great. The existing economic sectors in the municipality are based on fossil fuels and will have to reorient themselves towards new (sustainable) activities
- Realisation is expected after 2033/34
- On a gigawatt scale, the municipality has limited influence over permits and decision-making.

Other considerations

- The hydrogen economy fits well with the current gas treatment facilities and gas infrastructure.
- Den Helder is favourably located near vital gas infrastructure and also relatively close to current and future wind farms in the North Sea.
- Hydrogen can be used for the production of synthetic fuels, a large part of which can also be sold to the local port and airport.
- Blue hydrogen is not renewable and is a temporary solution. Blue hydrogen moreover requires large-scale capture and storage of CO₂, which requires a great deal of energy and has yet to prove itself. There is also a risk that green electricity for the process is withdrawn from other markets (RED III).
- The production, treatment and distribution of hydrogen or synthetic fuels involves high local energy consumption, which may be attributed to the city. This complicates Den Helder's ambition to become energy-neutral as a city.
- Den Helder may be in competition with other seaports such as IJmuiden, Harlingen and Amsterdam. Recent studies indicate, however, that a shortage of port space for offshore wind is looming and that there will therefore be no competition.

Assessment framework for transition scenarios (1/2)

The relevant indicators are grouped, in no particular order, under the themes energy, economy, living environment and other.

Energy and CO₂ emissions

- Contribution to (local) energy supply & security of supply
- Contribution to local sustainable energy production & lower CO₂ emissions
- Effect on grid load and the prevention or reduction of grid congestion

Economy and business climate

- Direct employment and (new) jobs
- Economic impact and (consequently) indirect jobs
- Investment in realisation (in the region)
- Regional knowledge and technology development and contribution to education

Healthy and safe living environment

- Claim on land, soil & space
- Safety (risk of fire, accidents, etc.)
- Ecology and spatial quality

Urgent and robust

- Support among the various stakeholders
- Realisation timeframe: before or after 2035
- Authority and autonomy of local decision-making.

Assessment framework for transition scenarios (2/2)

	Building blocks									
Indicators	Battery storage	Heat network	Solar fields	Large-scale digestion	Wave energy	H ₂ production via E (H2G)	SMR	Landfall E	Landfall H ₂	H ₂ production via G (H2B)
										
Energy / CO ₂				+	+		++	++	+	+
Economy	-	-	-			+	++	+		++
Living environment		+	-	-	+		-	--		-
Urgent / Robust	+	+			-		-	-	-	

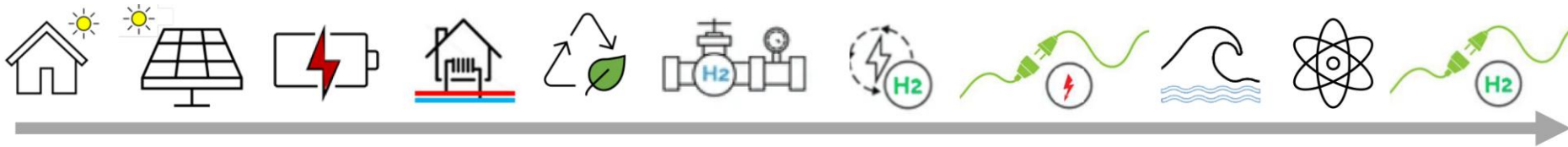
Table 1: Assessment framework with indicators and building blocks in outline (see the Appendix for a detailed substantiation). A blank cell implies a neutral score.

Transition scenarios (1/9)

In summary, it can be stated that the building blocks most desirable from the perspective of the municipality of Den Helder are determined by the selection of the most desirable indicators.

On the basis of the structure of the framework, four main pathways can then be identified. In order of increasing emphasis on the energy task and spatial impact, these are:

- Focus on the living environment
- Urgent & robust
- Economic development
- Focus on energy supply



Transition scenarios (2/9)

Transition pathway: Living environment

In this scenario there is a preference for technologies with as little effect on the living environment as possible and the smallest possible spatial impact.

- Building blocks are battery storage, rooftop solar, solar at infrastructure such as along roads, solar carports, insulation, heat pumps, small-scale heat networks and the like
- Owing to the risks of traffic, noise and odour nuisance and land use, large-scale digestion is not an option
- Energy from water is also uncertain within this scenario, as little is yet known about the ecological effects
- Owing to the substantial demand for very pure fresh water, large-scale electrolysis is not an option either
- Finally, it is logical to phase out large-scale solar fields (> 2 ha) gradually in order to create more space for nature and landscape development.

Relying mainly on small-scale technologies has advantages, such as a limited spatial footprint, but also consequences for the pace of the energy transition. It becomes virtually impossible for the city or the municipality to become energy-neutral or climate-neutral, even in the long term. Nor is there much of a business model, investment or employment associated with the energy transition. The decision not to allow large-scale electricity production may also hamper the achievement of, for example, the national RES targets.

This transition pathway requires little steering by the municipality.



Transition scenarios (3/9)

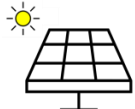
Transition pathway: Urgent & robust

In this scenario the focus is on the development of robust, widely supported energy sources that can contribute before 2030, or by 2035 at the latest, and for which decision-making rests with a limited number of (local) stakeholders.

- The main building block is large-scale digestion, supplemented by smaller sources such as battery storage, insulation, small-scale electrolysis, hybrid heat pumps, etc.
- Solar power plays a lesser role, because congestion problems will delay the development of solar power for a long period, although solar power can be deployed on a limited scale for own consumption (mainly on roofs) and what has already been built can remain in place until 2035.
- On the basis of current estimates, green hydrogen could also still be realised before 2035.
- The SMR probably cannot be realised before 2035 (period 2035–2040).

The main disadvantage of this transition pathway is the risk that insufficient attention is paid to promising developments and innovations that may emerge after 2035. Less attention is also paid to the production or landfall of sufficient renewable electricity, while demand for it is rising rapidly.

Above all, this scenario requires certainty that sufficient transport capacity will be available at Kooypunt before 2035 for the electricity needed for hydrogen production, and that hydrogen can be distributed via the national hydrogen network. Whether Den Helder can be connected to this network before 2035 is likewise uncertain.



Transition scenarios (4/9)

Transition pathway: Economic development

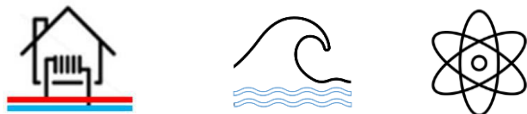
In this scenario the emphasis is on more economic development, employment and knowledge development.

- The most essential building block is the SMR, with an investment of more than €2 billion.
- To a lesser extent, wave energy (€250–500 million), large-scale digestion (€100 million) and local electrolysis form part of this scenario.
- Large heat networks could also form part of it, because they can make use of the residual heat from the SMR and/or electrolysis and substantial investment is required.

Energy can be used within the municipality or supplied to third parties ('hub function'). A consequence of selling energy to third parties, however, is that the municipality could not be regarded as energy-neutral.

The advantage is that only a limited number of building blocks are needed for the future. The disadvantage of this scenario is that the municipality is largely dependent on third parties for development and decision-making (TRL of wave energy, SMR developments). Another disadvantage is the spatial impact of deploying large-scale sources. Finally, relatively little can be realised before 2035.

Because this transition pathway requires a great deal of space, the municipality will have to acquire additional land and designate it for the energy task.



Transition scenarios (5/9)

Transition pathway: Energy

In this scenario the boundaries of the energy supply are stretched as far as possible. The emphasis is on as much (low-carbon) energy production as possible and the development of energy infrastructure.

- In fact all building blocks can contribute, although the emphasis on solar power (especially solar fields) may be somewhat less owing to its relatively limited energy yield
- An SMR is certainly an option within this scenario.

The advantages are, of course, a sufficient supply of energy as well as substantial investment in Den Helder and the region, with a correspondingly improved business climate and employment. The disadvantage is that a considerable claim will be made on the scarce available space, with a risk of deterioration of the living environment. Moreover, this scenario too suffers from the fact that several essential building blocks are not robust, because the municipality depends on third parties for decision-making.

In this scenario too, the municipality must acquire additional land and designate it for the energy task. The solar fields and the SMR in particular require a relatively large amount of space.



Transition scenarios (6/9)

Energy-neutral

Transition pathway: Energy-neutral

A variant of the Energy transition pathway is the selection of building blocks that contribute as much as possible to the municipality becoming energy-neutral.

- The choice of biomass as a building block is uncertain, because not all biomass originates from Den Helder. The assumption, however, is that the end products are (largely) sold within Den Helder and that production likewise takes place within the municipality.
- Part of the hydrogen production via electrolysis (H2G) could possibly be attributed to the municipality.
- For electricity from wave energy (tidal energy), the assumption is that the electricity makes landfall at Den Helder and is also used within the municipality.
- For the SMR, likewise, (part of) the electricity is used within the municipality.

However, the national accounting rules on whether or not (new) energy sources are attributed to municipalities and provinces have not yet been finalised and may also change. In any event, Den Helder will need to demonstrate that energy attributed to Den Helder is actually used within the municipality.

This can be done by entering into exclusive purchase and sales agreements for renewable energy. Examples are power purchase agreements (PPAs) between the producers and the end users in Den Helder, or green certificates, whereby residents and businesses in Den Helder become the owners of the certificates.



Transition scenarios (7/9)

Energy-neutral

Without the attribution of large-scale hydrogen production to Den Helder, two variants (molecules, electrons) remain for the municipality to become as energy-neutral as possible.

- **Molecules:** If the SMR is not realised, several other building blocks will have to be realised, including as many solar fields as possible, energy from water, battery storage and, to a lesser extent, large-scale digestion. In all likelihood, insufficient energy will still be generated for the municipality (i.e. the city including the civil and military ports) to become neutral, although the uncertainties are great. In any event, it is important to create a framework enabling small-scale hydrogen production (H2G) to be attributed to Den Helder.
- **Electrons:** If the SMR is realised, there will in principle be sufficient energy supply for a neutral municipality, including 'bunkering', and a certain surplus could possibly be sold to third parties.

The possibilities of becoming neutral are estimated to be greater than in earlier municipal analyses. The projected future energy consumption is lower, and the sustainable energy potential is higher, than estimated before 2020 (Raadsinformatieavond Energieneutraal, 2018).

Transition scenarios (8/9)

Climate-neutral

Transition pathway: Climate-neutral

A second variant of the earlier transition pathways is the selection of building blocks that contribute as much as possible to the municipality of Den Helder becoming climate-neutral.

- The use of bio-based feedstocks is a key building block, because under current legislation and regulations organic (residual) streams with a relatively short cycle are regarded as climate-neutral.
- Hydrogen is also a building block, because no local CO₂ emissions are associated with it. However, the use of hydrogen production is not necessary for the municipality to become climate-neutral.
- Likewise, local electricity production by means of, for example, an SMR is not necessary within this scenario either.
- Committing to as much electrification as possible (electric heat pumps, electric transport) is a precondition, because the resulting emissions are attributed to Den Helder on the basis of the Dutch generation mix, which is being made sustainable relatively quickly, mainly through offshore wind. The national Climate Agreement stipulates that by 2030 the share of renewable electricity in total electricity production will already exceed 70%.

Den Helder's emissions from industry and agriculture have already been virtually phased out (see the Appendix). What remains are the emissions within the built environment and traffic & transport sectors, and above all natural gas and fossil motor fuels.

The Climate-neutral transition scenario for 2040 is a realistic and achievable scenario. After all, compared with the 1995 peak, Den Helder's CO₂ emissions had already almost halved by the end of 2024 (Emissieregistratie and CBS CO₂ emissions estimate, Q3 2024).



Transition scenarios (9/9)

Spatial footprint

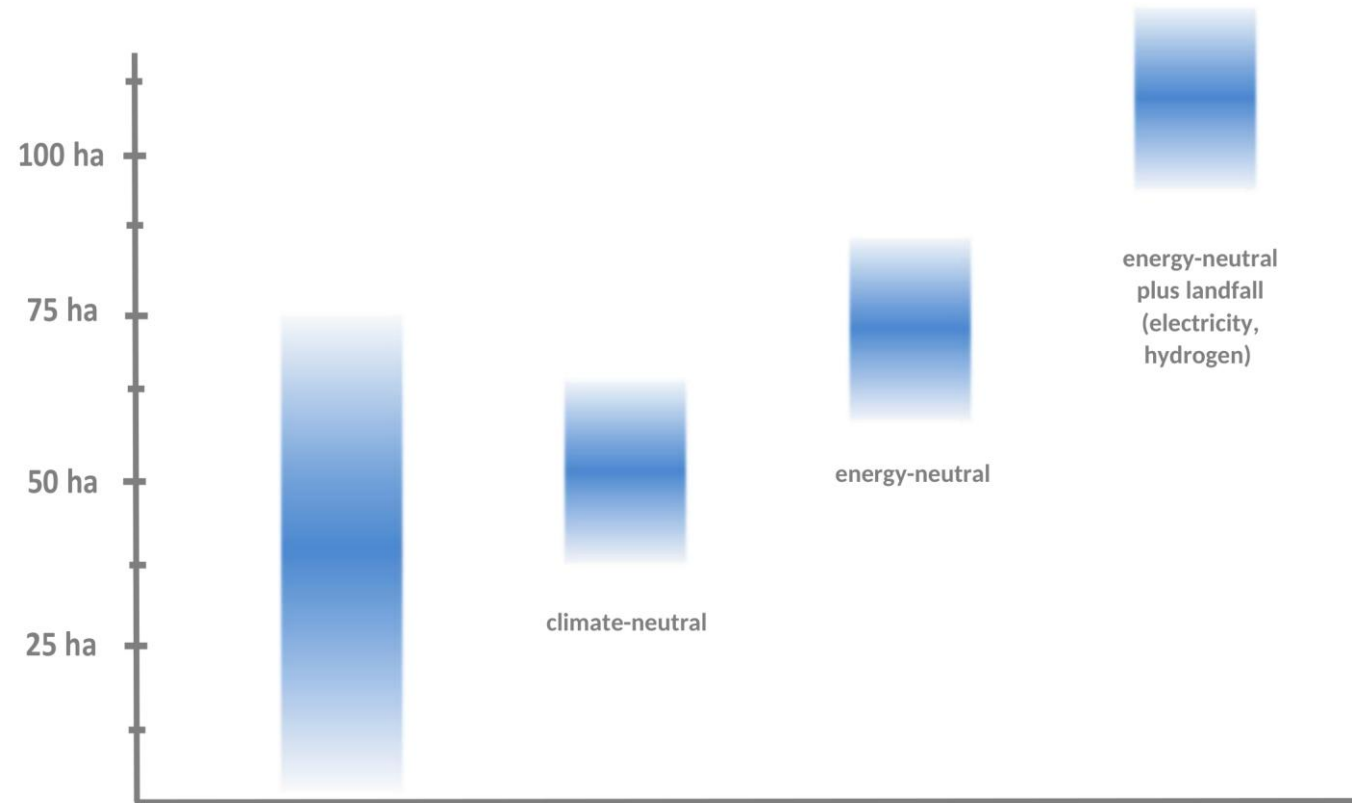


Figure 4: Bandwidth of the spatial footprint required for the Den Helder transition scenarios in hectares, supplemented with estimates for climate and energy neutrality and with the landfall of electricity & hydrogen from sea. The local spatial footprint can rise to more than 120 hectares if everything is realised.

Demand & supply (1/3)

Supply

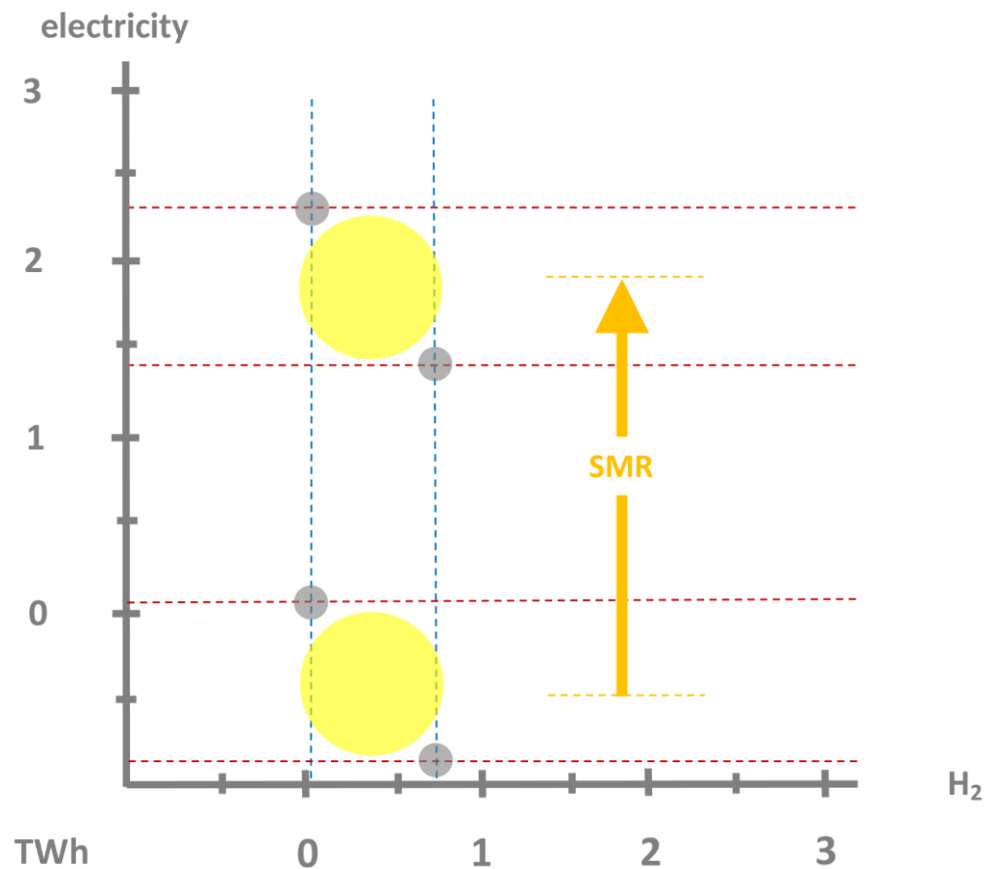


Figure 5: Den Helder transition scenarios in TWh (supply side, net), excluding the landfall of energy from the North Sea (electricity, hydrogen, natural gas to hydrogen). More hydrogen production leads to a lower supply of electricity, which can even become negative. The four scenarios in grey can de facto be reduced to two in light yellow (namely with / without SMR).

Demand & supply (2/3)

Demand & supply

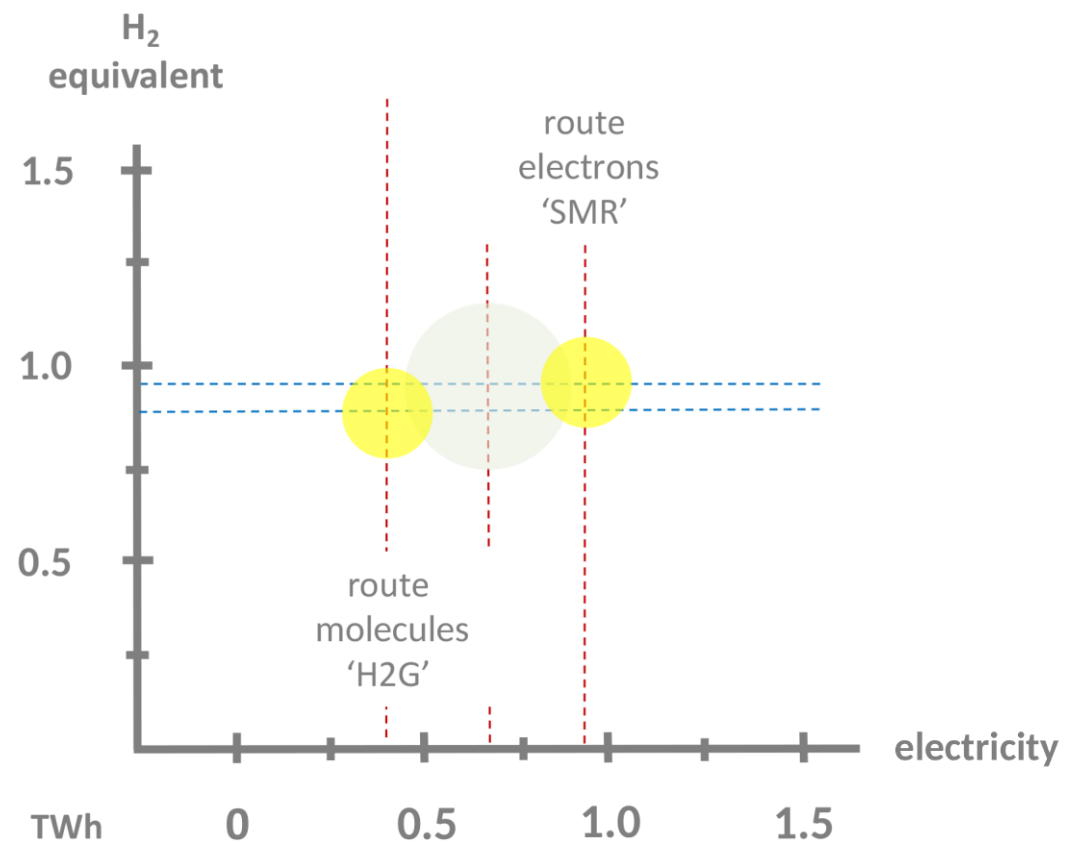


Figure 6: Municipality of Den Helder transition scenarios in TWh (demand side in green and supply side, gross, in yellow), excluding the landfall of energy from the North Sea (electricity, hydrogen, natural gas to hydrogen). The supply side concerns the 'Energy-neutral' sub-scenarios. Hydrogen may be in pure or bound form (for example via green gas or methanol).

Demand & supply (3/3)

Supply

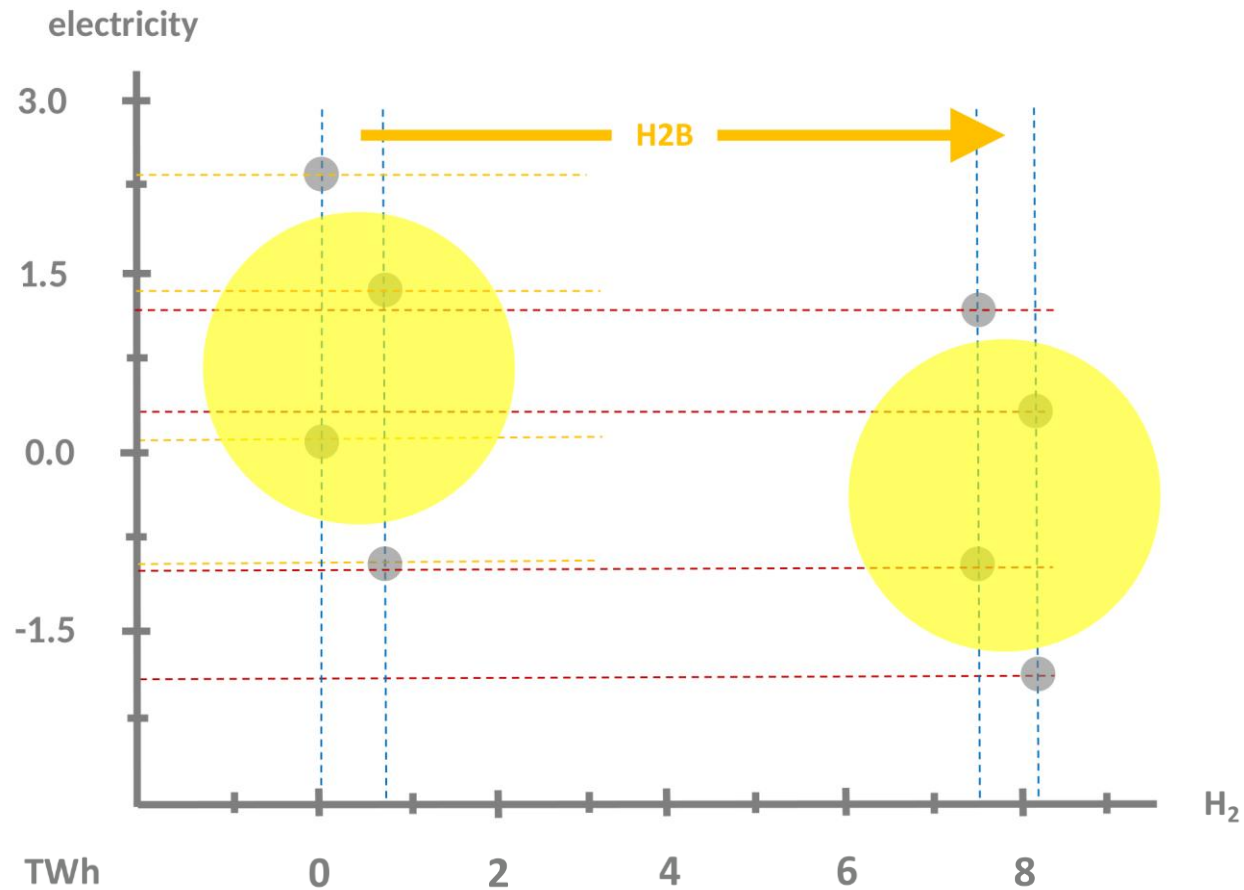


Figure 7: Den Helder transition scenarios in TWh (supply side, net), excluding the landfall of energy from the North Sea (electricity, hydrogen) and including natural gas to hydrogen (H2B). The eight scenarios can de facto be reduced to two (with/without H2B).

Key Performance Indicators (1/2)

A key performance indicator (KPI) is a performance indicator that reflects the progress of the energy transition. The proposal is to align with the indicators for Den Helder from the national Klimaatmonitor, although additional analysis is needed in some cases.

Energy indicators are in terajoules (TJ) and per year.

Energy

- Energy consumption, broken down into the built environment, traffic & transport, industry and agriculture
- Renewable energy consumption, broken down into the built environment, traffic & transport, industry and agriculture
- Electricity consumption, broken down into the built environment, traffic & transport, industry and agriculture
- Renewable electricity consumption, broken down into the built environment, traffic & transport, industry and agriculture
- Heat consumption, broken down into the built environment, industry and agriculture
- Renewable heat consumption, broken down into the built environment, industry and agriculture
- Consumption of renewable fuels for the traffic & transport sector (including biofuels, hydrogen).

Production of renewable energy

- Electricity generation broken down into the RES (> 15 kW) and small-scale systems (< 15 kW), and also broken down into solar & wind
- Local production of renewable heat (green gas, residual heat, ambient energy)
- Local production and use of (blue and green) hydrogen per year.

Key Performance Indicators (2/2)

CO₂

CO₂ indicators are in kilotonnes (kton) and per year.

- CO₂ emissions, broken down into the built environment, traffic & transport, industry and agriculture
- Total emissions of other greenhouse gases
- Total CO₂ emissions avoided as a result of local production of renewable energy.

Other

Other indicators are desirable – this information is not always available in public sources.

- Consumption of liquid fuels in sea shipping and the airport in TJ and million litres per year
- Installed peak capacity of large-scale electricity storage in megawatts
- Area of large-scale solar parks in hectares, as well as installed peak capacity in megawatts electric
- Area of rooftop solar in hectares, broken down into small and large roofs (via [zonnedakje.nl](https://www.zonnedakje.nl))
- Installed peak capacity of wind energy in megawatts
- Number of demonstration projects relating to innovation (including energy from water, hydrogen, new forms of energy storage and the like)
- Use of biomass per year in both kton and TJ, broken down into woody biomass (thermal conversion) and (liquid) organic residual streams such as manure, roadside grass and straw (biological conversion)
- Share of biomass originating from outside the municipal boundaries
- Capacity brought ashore from offshore wind, broken down into electricity and hydrogen
- Solar and wind capacity in the pipeline (via, among others, the SDE++ scheme, EIA and permit applications).

Appendix

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Energy Assessment Framework

CO₂ emissions

Sources

List of definitions



Scope

A distinction is made between local, municipal and regional energy consumption, or generation.

City of Den Helder

Den Helder as a city means that all local energy consumption within the core of the municipality of Den Helder (built environment, business parks, road traffic, rail traffic, agriculture, industry, inland shipping, fisheries, shore power, et cetera) is included. This is also in line with the national Klimaatmonitor.

The consumption of the bunkering facilities for sea shipping (offshore, Royal Netherlands Navy) is not attributed to Den Helder as a city. TESO is attributed half to Texel and half to Den Helder.

Municipality of Den Helder

This means all energy consumption including the bunkering facilities for sea shipping (offshore, Royal Netherlands Navy) and aviation. The combined consumption of the civil and military (air)ports is comparable to that of the city (both around 1 TWh and together around 2 TWh per year).

Regional

Regional refers to consumption in the Kop van Noord-Holland region (Texel, Schagen, Den Helder and Hollands Kroon). These are the municipalities as local entities, including the consumption of liquid fossil fuels in the ports for sea shipping, the use of kerosene by the airport, greenhouse horticulture and the data centres.

General Assumptions (1/2)

The municipality of Den Helder has the ambition to be energy-neutral by 2040. This means that as much (sustainable) energy is generated within the municipal boundaries as is consumed. The municipality also aims to reduce CO₂ emissions by 60% by 2030.

It is not necessary for generation to equal consumption at every moment, only on average. Likewise, not every sector needs to be neutral in itself. Finally, it is not necessary for as much electricity to be generated as is consumed; one option, for example, is for more green gas or liquid renewable hydrogen to be generated locally than is consumed, compensating for the (possible) electricity shortfall. From a system perspective, however, it is desirable for demand and supply to be in balance per sector, per energy carrier and over time.

If (liquid) biomass is brought in from outside Den Helder but converted within Den Helder, the production is attributed to Den Helder.

If energy from the North Sea (natural gas, wind energy, etc.) is brought in and converted, this is not attributed to Den Helder. It may, however, be attributed if energy from inland waters such as the Wadden Sea, the Marsdiep and the IJsselmeer is used. This also applies if, for example, seaweed from the North Sea or elsewhere is converted within the municipality. These accounting rules may change.

Electricity consumption resulting from electrolysis to produce, for example, hydrogen, ammonia or methanol is attributed to the municipality in which production takes place. This is also the case in the current situation, where, for example, the electricity consumption of NAM for gas treatment and for shore power in the port is attributed to the municipality of Den Helder. However, the national and international accounting rules in this regard are not (yet) clear, and these rules too may change. It should also be borne in mind that the proceeds of electrolysis partly benefit the municipality concerned (in this case Den Helder). The assumption is that parties in the chain can make agreements on this.

General Assumptions (2/2)

The classification of the various energy sources as local versus (supra-)regional is based on capacity:

- Local is on a kilowatt and megawatt scale: solar energy, wind energy, heat, green gas, energy from water, small-scale electrolysis (H2B) and the SMR.
- Regional/supra-regional is on a gigawatt scale: landfall of electricity, landfall of hydrogen (both VAWOZ) and large-scale hydrogen from natural gas (H2Gateway, or H2B). Electrolysis on a gigawatt scale (> 500 MW) also falls into this category.

Fuel consumption in the Den Helder port area

(Liquid) fuel consumption within the port area (civil and military) is separated from that of the city.

- The calculated average liquid fuel consumption in the area in recent years is around 100 million litres per year. This consumption includes the airport, Kooyhaven, Texel, etc.
- Depending on future developments, total consumption may either increase or decrease.
- In view of the planned expansion of the Ministry of Defence, consumption by the Royal Netherlands Navy will in all likelihood increase.
- If 100 million litres of diesel (equivalents) were to be replaced entirely by (synthetic) fuels, more than 250 megawatts of renewable electrical capacity would be required.

Baseline scenario Den Helder (1/3)

The assumptions of the long-term baseline scenario are that:

- The city of Den Helder is (virtually) energy-neutral in 2040.
- National policy and legislation and regulations ('Climate Agreement') are complied with, such as the (scheduled) obligations for green gas, hybrid heat pumps and shore power.
- Projects at an advanced stage, such as geothermal heat, shore power, digestion (RWZI, NEN), Helder II, electrification of TESO, 'Zephyros' and the like, go ahead.
- There is consensus that most sectors will in due course be around two-thirds electrified. Exceptions are sea shipping, aviation and greenhouse horticulture. Nor does it apply to energy-intensive agriculture and industry, but these sectors are barely present in the region, if at all. 'In due course' means around 2040.
- The use of sustainable woody biomass is limited and will increase only marginally towards 2040.
- As a result of savings and energy efficiency, the volume of consumption decreases by around 5%, with the exception of the built environment, where savings have a greater effect (5–10%). This is based on historical CBS data for the Netherlands.
- For shore power, 2 x 25 MW at part load (5,000–6,000 hours per year) is assumed.
- Calculations are based on an average heat pump efficiency (COP) of 3.5 and on an electric motor that is on average twice as efficient as a combustion engine/fuel cell.
- For energy production installations, including heat, it is assumed that 5–15% electrical energy is required for a given quantity of energy.

Baseline scenario Den Helder (2/3)

Energy balance of the city of Den Helder

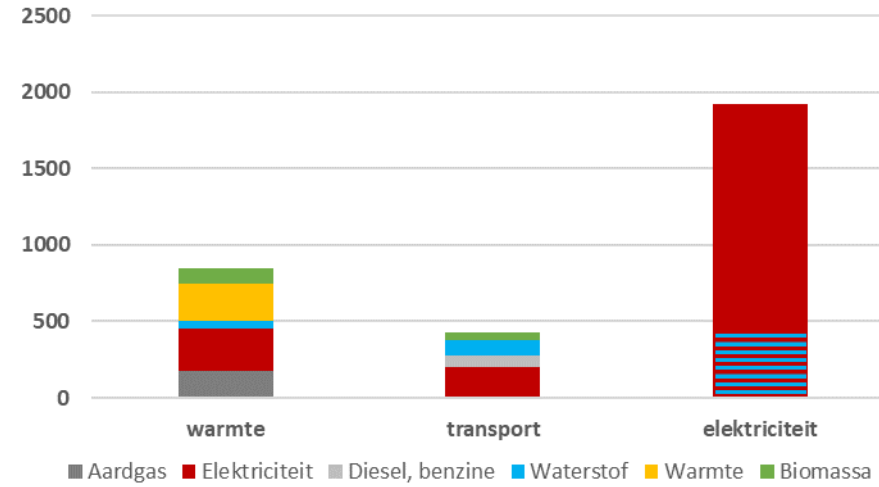
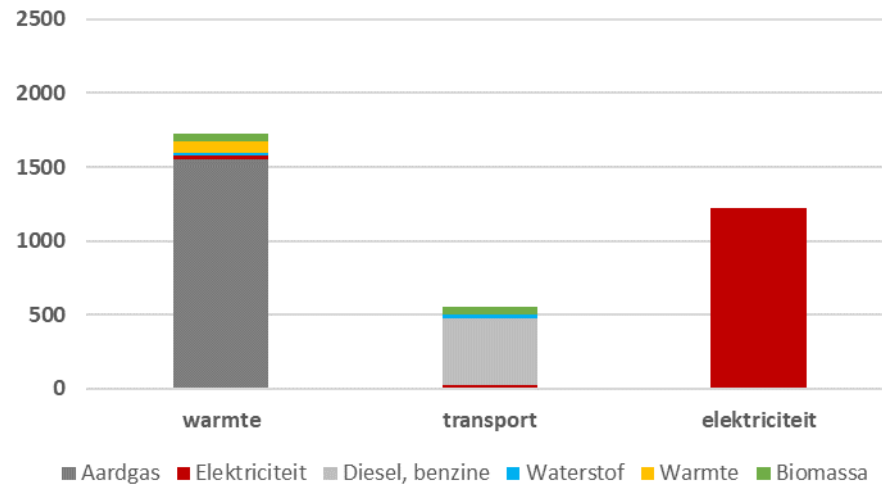


Figure 8: Indicative breakdown of the energy consumption of the city of Den Helder in terajoules (TJ), excluding bunker fuels for sea shipping, large-scale hydrogen et cetera, now (left) and in the future (right). Part of the electricity may be provided from storage (batteries, hydrogen), but this does not change end use (hence hatched). *Legend: warmte = heat, transport = transport, elektriciteit = electricity; Aardgas = natural gas, Elektriciteit = electricity, Diesel, benzine = diesel, petrol, Waterstof = hydrogen, Warmte = heat, Biomassa = biomass.*

1 TWh = 1,000 GWh = 3,600 TJ

Source: Klimaatmonitor and own analysis.

Baseline scenario Den Helder (3/3)

Electricity balance of the city of Den Helder

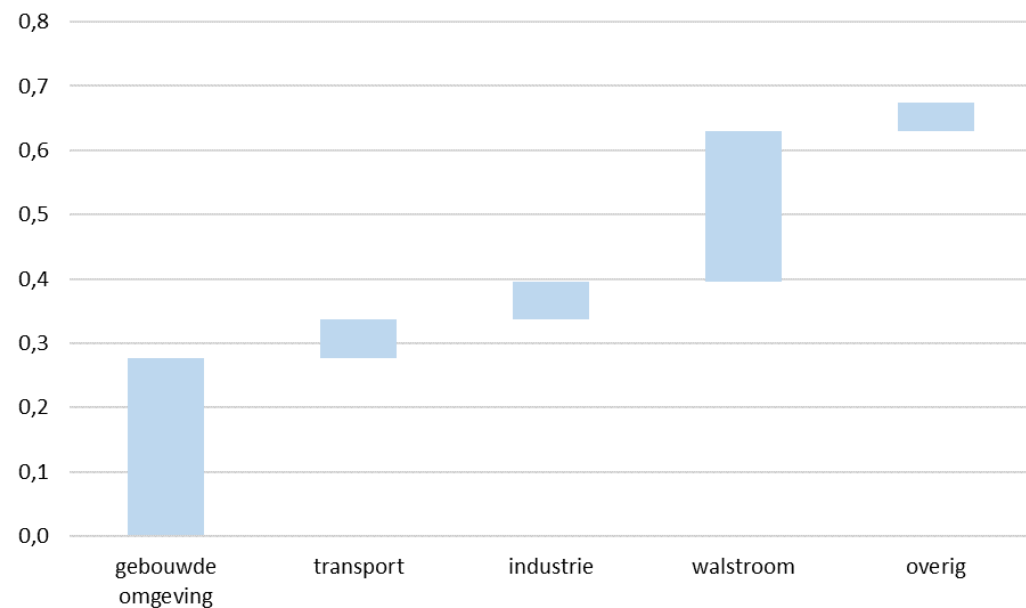


Figure 9: Indicative composition of the future electricity consumption of the city of Den Helder in terawatt-hours (TWh), excluding the electricity needed for bunker fuels for sea shipping, large-scale production of hydrogen (carriers) et cetera. *Legend: gebouwde omgeving = built environment, transport = transport, industrie = industry, walstroom = shore power, overig = other.*

1 TWh = 1,000 GWh = 3,600 TJ

Source: Klimaatmonitor and own analysis.

Sankey Den Helder (1/2)

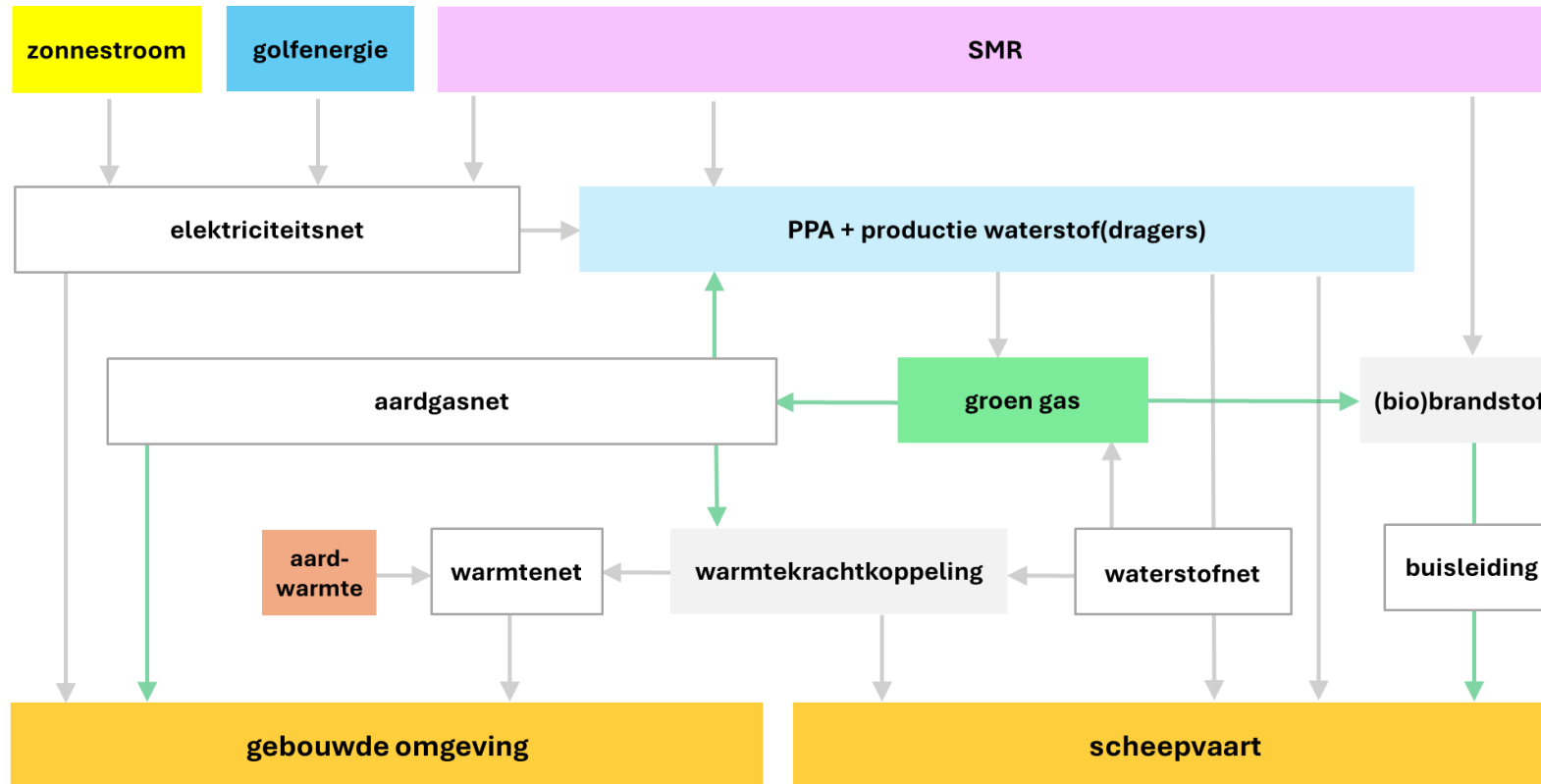


Figure 10: Sankey diagram of energy flows in Den Helder (example). *Legend: zonnestroom = solar power; golfenergie = wave energy; elektriciteitsnet = electricity grid; PPA + productie waterstof(dragers) = PPA + production of hydrogen (carriers); aardgasnet = gas grid; groen gas = green gas; (bio)brandstof = (bio)fuel; aardwarmte = geothermal heat; warmtenet = heat network; warmtekrachtkoppeling = combined heat and power; waterstofnet = hydrogen network; buisleiding = pipeline; gebouwde omgeving = built environment; scheepvaart = shipping.*

Sankey diagram Den Helder (2/2)

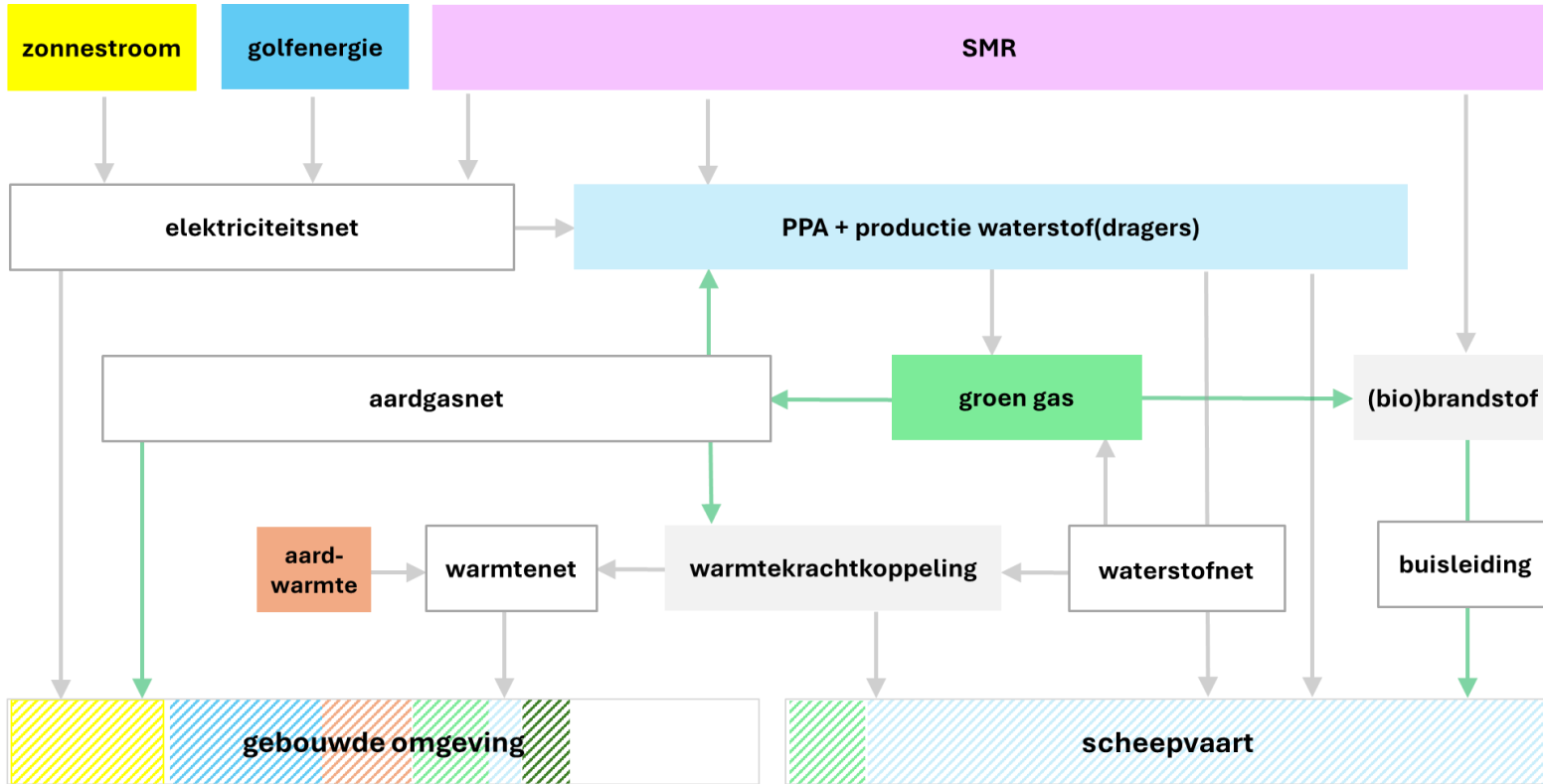
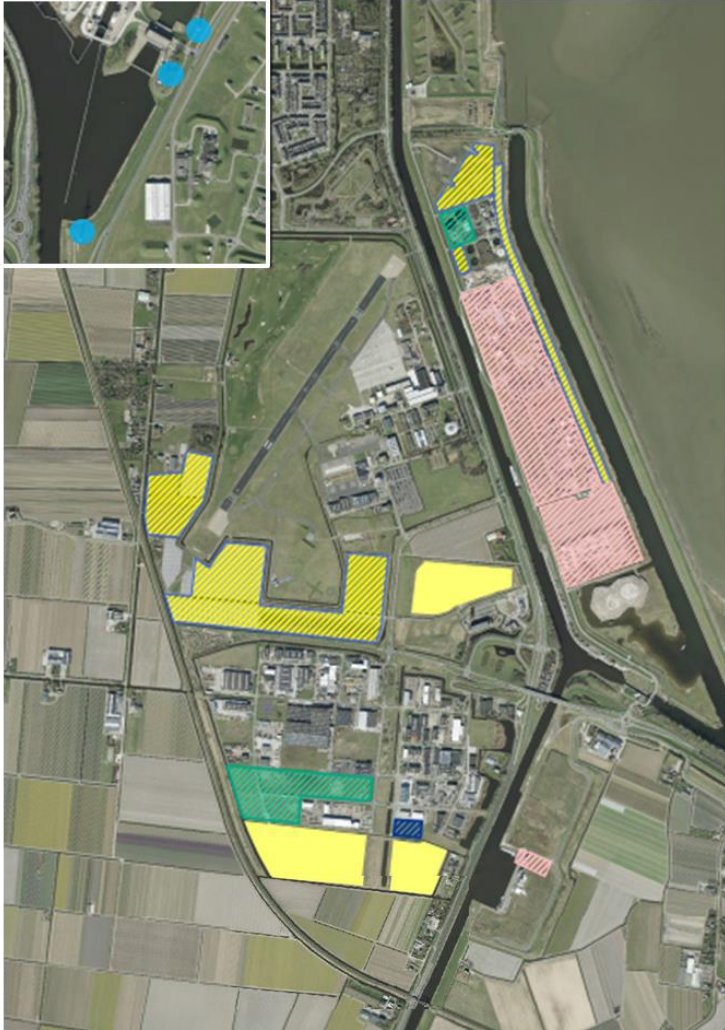


Figure 11: Sankey diagram with distribution of energy flows in Den Helder (example). For the English translation to the labels, see Figure 10.

Map of Kooypunt/Oostoever



- Yellow = solar fields
- Green = green gas
- Pink = hydrogen
- Dark blue = battery storage
- Light blue = wind (> 15 metres)
- SMR = to be determined
- Hatched = initiative phase with land position

The bandwidth of the spatial footprint of (future) energy projects, including landfall, is around 100–120 ha.

Figure 12: Map of Kooypunt/Oostoever.

Overview of the hydrogen market and initiatives

The calculations below assume that the hydrogen is produced locally. As a result, local electricity demand could increase by well over 2 TWh per year.

Small-scale

- Estimated production is 0.2 kton per year in 2026 (0.03 PJ)
- Average yield is around 70%
- Electricity requirement is 0.01 TWh (1.5 megawatts at 7000 hours of production)

Liquid hydrogen

- Estimated production is 5 kton per year (0.6 PJ)
- Yield is 65% (75% electrolysis and 10% liquefaction, etc.)
- Electricity requirement is 0.28 TWh (40 megawatts at 7000 hours of production)

Green hydrogen (H2G)

- Estimated production is 15–20 kton per year (2.5 PJ)
- Yield is 70% (75% electrolysis and 5% compression, etc.)
- Electricity requirement is 1.0 TWh (140 megawatts at 7000 hours of production or 200 megawatts at 5000 hours)
- Not before 2033/2034

Blue hydrogen (H2B)

- Estimated production is 200 kton per year (25 PJ)
- Electricity requirement is well over 0.8 TWh (120 megawatts at 7000 hours of production or 170 megawatts at 5000 hours)
- Not before 2033/2034

Assessment framework for transition scenarios

	Building blocks									
Indicators	Battery storage	Heat network	Solar fields	Large-scale digestion	Wave energy	H ₂ production via E	SMR	Landfall E	Landfall H ₂	H ₂ production via G
Energy supply	- / +	- / +	+	+	+	++	++	+++	+++	+++
Sustainable local energy production	-	- / +	+	+	++	- / +	- / +	--	--	- / +
Grid load	+++	++	---	- / +	- / +	---	++	+++	+	---
Direct employment	--	--	-	- / +	-	- / +	+	+	+	++
Indirect employment	- / +	-	-	- / +	-	+	+	+	+	+
Investments	- / +	+	- / +	+	++	+	+++	+	- / +	+++
Knowledge development	-	-	-	+	+	++	+++	-	- / +	++
Spatial footprint	+	+	---	--	+++	- / +	--	---	-	--
Safety	-	++	- / +	- / +	- / +	- / +	-	- / +	- / +	- / +
Spatial quality	-	+	- / +	--	- / +	--	-	---	- / +	-
Public support	- / +	-	---	-	- / +	- / +	- / +	-	+	+
Realisation timeframe	+++	++	++	+++	---	-	---	-	---	-
Local decision-making	+	++	+	- / +	- / +	- / +	- / +	--	--	-

CO₂ emissions Den Helder

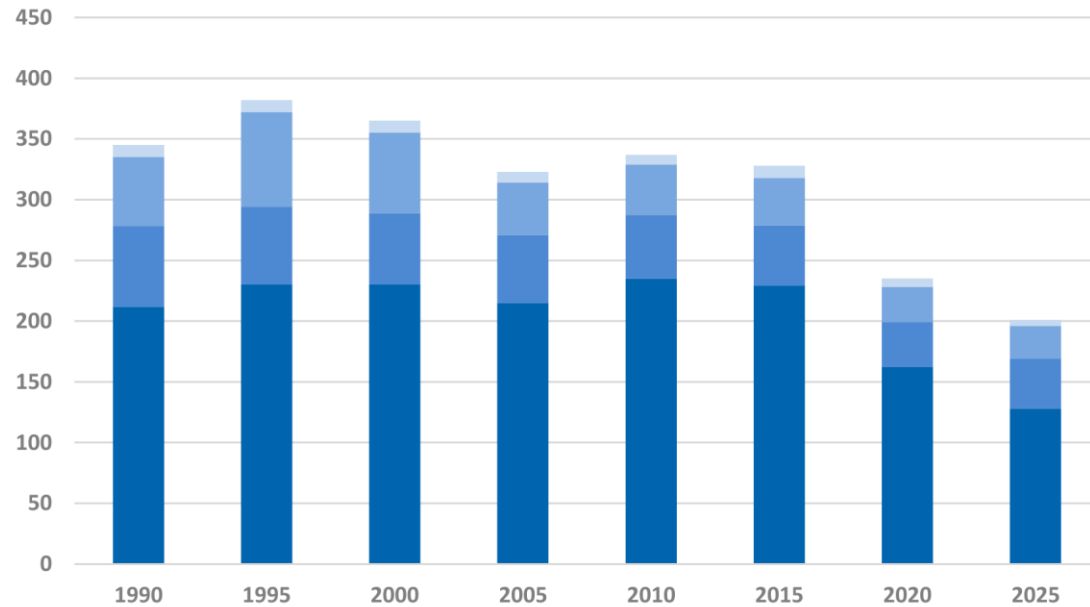


Figure 13: Indicative annual CO₂ emissions in Den Helder in kton according to the consumption-based approach, excluding (sea) shipping and aviation, for the built environment, traffic & transport, industry and agriculture.

Source: Klimaatmonitor, Emissieregistratie, CBS and own analysis.

Sources (1/4)

Data / GIS

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- Warmtenet Den Helder: <https://www.warmtenetdenhelder.nl/>
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- https://atb.nrel.gov/electricity/2024/utility-scale_battery_storage

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List of definitions

- Energy-neutral = all energy generated within the municipal boundaries is also used within the municipality
- SMR = Small Modular Reactor (nuclear reactor < 500 megawatts electric)
- H2B = blue hydrogen (via ‘reforming’ using natural gas from the North Sea as the source, combined with CO₂ storage)
- H2G = green hydrogen (via electrolysis, using mainly offshore wind as the source)
- Bunker fuels = (liquid) fuels for (sea) shipping and aviation
- Green gas = biogas upgraded to natural gas quality and injected into the natural gas grid
- HVO diesel = ‘Hydrotreated Vegetable Oil’, a renewable diesel fuel
- City of Den Helder = the city of Den Helder including Julianadorp and Huisduinen and including the business parks, but excluding bunkering
- Municipality of Den Helder = the city of Den Helder including the business parks and including bunkering in the port(s) and airport(s)
- Den Helder region = the Kop van Noord-Holland (Texel, Schagen, Den Helder and Hollands Kroon) including the (air)port(s)
- Congestion management = allocating the limited capacity on the electricity grid at times when demand for electricity transport exceeds what the electricity grid can handle
- KPI = Key Performance Indicator – a performance indicator that reflects the progress of the energy transition
- pMIEK = provincial Multi-year Programme for Energy and Climate Infrastructure (provinciaal Meerjarenprogramma Infrastructuur Energie en Klimaat)
- PODH = NV Port of Den Helder
- TESO = Koninklijke NV Texels Eigen Stoomboot Onderneming (Royal Texel Steamship Company)
- RES = Regional Energy Strategy (Regionale Energie Strategie; solar & wind > 15 kilowatts)
- VAWOZ = Programme for Offshore Wind Landfall Connections (Programma Verbindingen Aanlanding Wind Op Zee)
- CHP (WKK) = combined heat and power – the combined generation of both electricity and heat
- Solar fields are solar parks > 2 ha (solar parks can also be smaller).