2030 Climate Neutrality Action Plan

Groningen

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1 Reading Guide

This Climate Action Plan (CAP) is the first incarnation of a cycle of updated CAPs for the duration of the Mission 2030: 100 Climate Neutral and Smart Cities (CNSC). It is intended to give a starting point, a status quo, of the Groningen mission.

Therefore, it will tell the Groningen narrative show the GHG emissions inventory, a listing of current policies and actions and identified systemic blockades and already identified future pathways of actions, it may show lacunes in available data or gaps in policy, but it will not suggest or venture into new pathways and or new policies.

The making of policy suggestions and the consequential process of deciding on policies, budgets and other assets is complex, and subject to legal conditions, such as approval by the board of mayor and vice-mayors and the democratically elected municipal council. The timeframe of making this first CAP is not yet aligned to the timeframes of policymaking and the timeframes of reporting and budgeting by the municipal council.

The actions and policies in this document have been approved by the apt public body and where new policies or actions are in the making, this will be noted in this document.

This CAP is loosely based on the NetZeroCities (NZC) template and theory of transition. The NZC approach is well–thought-out, elegant and comprehensive. In a greenfield situation it is the approach of choice. However, Groningen is working from a situation where the design of our policies has evaluated over many years, in an existing organisation with long-proved relationships in society. Many of the policies to reduce GHG emissions are already in execution and some have been so for years.

So, in a way, this plan is not a plan. It is a document to show the European Commission the state of affairs in Groningen, and our intentions to fulfil our role as a mission city in the Mission 2030: 100 Climate Neutral and Smart Cities. Together with the Commitment Document and with the Climate Neutrality Investment Plan, it shows the intentions and the committed assets of Groningen towards a CO2 neutral future.

- Chapter 2 is intended to give a quick overview of what Groningen is doing to reach climate neutrality.
- Chapter 3 is background information on Groningen: history, statistics.
- Chapter 4 Details the current state of action: baseline, policies, stakeholders and barriers

- Chapter 5 details how Groningen wants to reach climate neutrality: models, actions, pathways and indicators
- Chapter 6 is about how Groningen is interacting with society: participation, governance and social interventions
- Chapter 7 looks into the follow up on this plan: what can we do to improve, when are we going to reiterate the planning

Update September 5th 2025
The appendices now include 2 additions that have been added after the initial submission in September 2024: the Joint Statement of the Dutch Cities (March 2025) and a reaction on the feedback of the JRC on the Groningen CCC (September 2025). These appendices will give further understanding of the Groningen CCC.

For now, let's start with the Groningen approach in a nutshell!

2 The Groningen approach in a nutshell

2.1 From society, by society, for society

Groningen has very opiniated views on reaching a sustainable and climate-neutral energy system and has had these views consistently for a long time.

First of all, we see the energy system as a commons. It should be managed to have maximal societal benefit. However, the system has been privatized and divided into different (regulated) markets, such as production, transport, distribution, trade and storage. The players in these markets maximize share-holder value, not societal value. This loss of value for society, often in terms of money, is hindering the transition towards a climate-neutral system. Competition between players does not necessarily mean a better working system or more innovation, it often means protection of the most capital intensive and fossil dependant companies.

In Groningen we try to counteract that by managing our own local system locally, as much as possible. This means that the municipality started its own energy company, and its own municipal heat grid. We even manage our own public charging infrastructure! This means that we can influence the impact on public space, and that we can channel profits back into the local community. Some parts of the system, such as solar parks, are managed by local cooperations. Groningen actively supports these initiatives, while actively discouraging initiatives that are not based in the local community.

In our local community, some people are struggling to get by, financially, or in terms of inclusion into our society. A bit of support to those people will go a long way in preventing societal costs: health, welfare, education, employment. We use the profits of our energy company to help those who need it first, and those who can afford the transition, will follow.

2.2 When and how do we reach climate-neutrality?

As a mission-city, we aspire to reach climate neutrality in 2030. But we know that a city such as Groningen, has limited influence on the reduction of Green House Gases (GHG's). However, the city can accelerate the reduction of GHG's by actions and foresee more actions in the future (pathways). So, basically, the total reduction of GHG's in the future is the sum of ‘autonomous’ or national influence on reduction, the reduction due to local actions and the reduction due to identified local pathways.

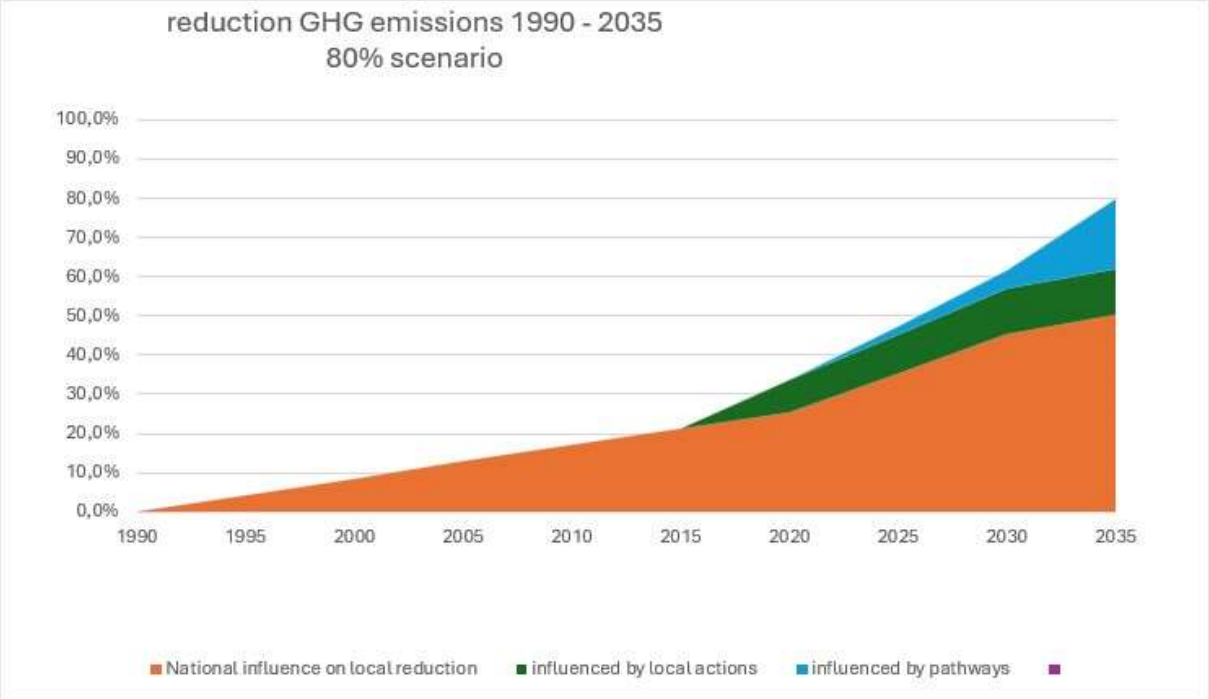


Figure 1 GHG reduction scenario Groningen 1990-2035

We don't know exactly how the future will look. But we expect that Groningen will reach a 60% reduction by 2030, of which some 15% points is by local influence. In other words, we expect that Groningen will outperform the national Dutch average by even a larger margin than we had in 2020 (where we performed 8.1% points better than the national average. We expect that in 2035 this should be at least 29,5% points better than the national average. We estimate that by 2035, we will use almost 100% of the opportunities that a local government has to curb the emissions if GHG's!

To reach these goals, we have committed resources for the actions described in this plan. For the pathways, these resources have not been committed yet, but are likely to get committed in the period until 2030.

In total, we expect that the Groningen stakeholders will need to have invested € 4,25 Billion by 2030.

2.3 So, what is Groningen doing to get to CO2 neutrality asap?

Built environment:

Groningen builds its own publicly owned heat grid. Already some 6000 homes have been connected. The heat grid is fed by sustainable sources: residual heat from data centres and Europe's largest solar collector plant.

We started in those districts that needed renovation most, with an intensive door-to-door approach. The offer is a package of connection to the heat grid, isolation/retrofit of the home, subsidy and other financial incentives, and even turn-key solutions by a by Groningen selected contractor.

The end goal is that every home in Groningen should reach 'isolation standard' (47kW/m^2), and we can put serious money where our mouth is!

When digging in the streets for the construction of the heat grid, it is combined with renovation of the sewage-system (climate adaptation) and redesign of public space (less cars, even more bike friendly, green for shade and rainwater retention). This combination asks for a lot of coordination, but it will pay out in savings on public funds spent.

Energy system

Groningen established her own energy company. This company will exploit sustainable energy sources in the municipality, together with local cooperatives. These sources include large PV installations (already 3 are in operation) and wind power. The profits of this enterprise will flow into the Energy Transition Fund, which is used to include low-income households in the transition. Municipal regulations demand at least 51% local ownership for all large PV and wind installations, and there are strict rules on participation and compensation for those who live in the vicinity of these plants.

Mobility

You won't find a city that is as bike intensive as Groningen anywhere in Europe, and arguably in the world. Groningen is a 15-minute city, by bike or Public Transport, you'll be able to reach any point in the city within 15 minutes. By car it will take longer. Also, in the domain of mobility, the municipality does not hesitate to take charge. Literally, by the way, public charging infrastructure is managed by the municipality, and profits will flow back into society. Groningen is abandoning the logic of using cars in the city: it takes an unhealthy large toll on public space. Less parking, lower max. speed, more shared mobility, emission-free public transport (already in the city itself), more space for pedestrians and bikes, and from 2025 mandatory emission-free freight logistics for the city center.

Plant-based

Though as a municipality we don't have a lot of influence on agriculture (which does take place in the eastern part of our municipality, Groningen is the first municipality in the Netherlands with a program for transition towards plant-based proteins. Plant-based proteins are better for health, for the environment (including CO2, CH4 and NOx emissions) and for animal welfare, so there is every reason to set the bar high.

Also, in terms of the construction of building, plant-based is better! Groningen pushes the regulatory frames towards more bio-based construction, and towards the change in agriculture that is needed for that.

Waste

Groningen people don't like to waste time and materials. In our vision, waste does not exist. It is either recyclable or used as a source of energy. We plan to reuse 100% of our waste by 2030, and we are well on the way towards it!

Leading in innovation

One third of our population is student at one of our 2 universities. These universities are the major employers of the municipality. No wonder that we value innovation, with specialities as Health and, of course, Energy. On our Zernike Campus there is a large real life energy infrastructure to test new technologies, such as hydrogen generation, heat pumps, fermentation techniques and energy storage. The municipality itself is a testbed for new energy solutions: Positive Energy Districts, hydrogen in our fleet. Yes, the company car of our mayor is running on hydrogen, the first in the Netherlands!

Inclusion

Inclusion of all inhabitants is a must. Equal as the Dutch society already is, there are still differences in wealth, wellbeing, health and integration in society. Not only from a Groningen political standpoint is this unacceptable, to reach netzero we actually need to include all, otherwise we will not reach our goals. Groningen has identified vulnerable groups, such as families with an income under 140% of the legal minimum and has started actions to make the transition to netzero accessible for these groups. Groningen has not just financial instruments for them, we tailor solutions from income support to turn-key retrofitting of homes, and while we are in contact with those targetgroups, we also offer support for other problems, such as health, education, employability and language skills.

2.4 Every silver lining has its cloud

Yes, Groningen is on the forefront of combatting GHG emissions, but we face our difficulties. The task ahead, building on our heat grid, retrofitting most homes in Groningen, adaptation to the change of our climate, is huge. We don't have enough 'hands' to do all the work. And already, we are short of workers to tackle another societal problem in Groningen: widespread damage due to gas-mining induced earthquakes.

The second and maybe most pressing problem: our electric system is congested, there is no room for more local production and for more local demand. On every level of our electric system the Netherlands faces gridlock. And there is no quick fix, because we lack workforce and materials to tackle it quickly. A good electric system is a condition for the transition towards climate neutrality, and it may take years to reach that.

This means that Groningen, though we really want to become climate Neutral by 2030, in reality hopes to reach climate neutrality by 2035. And even that is a very ambitious goal.

And yes, Groningen also faces financial and regulatory issues, things all Mission Cities face. But we see the silver linings around the clouds: if we have good plans, good solutions will follow!

3 Introduction into Groningen

3.1 Geography

The municipality of Groningen is situated in the North-Eastern part of the Netherlands, between the former floodplains of the Waddenzee, the peatlands of Eastern and Western Groningen and the Hondsrug, a sandy ridge deposited after the last Ice Age, between the small rivers of the Hunze and Reitdiep. Now 40km inland, Groningen used to be a seaport, connected to the Waddensea by tidal rivers. Groningen was part of the Hanze trade union.

Nowadays, it is by far the largest city in the Northern Netherlands, and the sixth largest city in the Netherlands (238.147 residents, Jan 1st, 2023). It consists of the city of Groningen, the mayor villages of Haren, Hoogkerk and Ten Boer, and 17 smaller villages. The total area of the municipality is 197,96 km2. Groningen is a university-city (some 70.000 students), as a result, the average age of the population is the lowest in the Netherlands. The population of Groningen is still growing, mostly owing to migration.

Figure 2 Map of the municipality of Groningen

The Groningen economy is mainly in the tertiary sector (education, care, government services), the main industrial activity is a large sugar factory (COSUN) which is also the largest user of energy (in the ETS system). The largest employer in Groningen is the University Medical Centre Groningen (UMCG), one of the 2 major hospitals in Groningen. UMCG is also a very large consumer of energy (ETS). Almost every enterprise in Groningen is small or medium sized, there is no heavy industry or petrochemical industry within the administrative boundaries.

Groningen is not just a city; it also encompasses peri-urban and rural areas. Agriculture is part of the rural economy, with mostly dairy farms, and sugar beet and potato farms.

Groningen does have a deep sea port (Groningen Seaports), but the port is some 40 km north of the city, administratively in the municipalities of Eemsdelta (Port of Delfzijl) and Hogeland (Eemshaven). Around these harbours, there is heavy industry, petrochemical industry, the largest power plant in the Netherlands and large-scale datacentres (Google). Also, outside the municipality of Groningen, on the territory of the municipality of Tynaarlo, is Groningen-Eelde Airport, a small airport that caters for some charter flights, the KLM flight school and small private airplanes.

Groningen is located at the end of the national railway connection to Zwolle, Utrecht, Amsterdam, and is a railway hub for regional railways to Leeuwarden, Winschoten/Leer (Germany), Delfzijl and Roodeschool/Eemshaven.

By road, Groningen is connected with motorways to Amsterdam (A7), Zwolle/Utrecht (A28) and Bremen/Hamburg (A7 towards Germany). These motorways intersect within the city-limits and encompasses part of a ring road around the city. A reconstruction of this section, removing traffic lights and tunnelling a major part of the section has been completed in September 2024, thus removing a lot of traffic congestion and pollution.

Groningen is the focus of a larger daily urban system, ranging some 80 km around the city, and attracting some 185.000 daily commuters.

The city of Groningen itself is very compact, with a city centre surrounded by canals within the 16th century bastion, a first layer of residential areas from the late 19th century, early 20th century, a ring road, and larger residential areas from the later 20th century and the 21st century outside the ring road. The city centre itself has a mixed commercial and residential function; industrial areas are mainly located outside the ring road. There are 2 main university campuses, the Zernike Campus, NW of the city and the University Medical Centre Groningen (UMCG) campus, which encompasses the largest university hospital in the Netherlands (1339 beds, 12.871 employees (2017), research facilities, education facilities and commercial estates. Atypically for a city but

defining for Groningen is that this campus is located within the inner city, on walking distance of the core of the city, the Grote Markt and the Martini Church.

Due to the compactness of the city, and a long-standing tradition of discouraging motor traffic in the city (since 1973 the city centre is free of transit traffic, and mostly car free), Groningen can be proud of being the biking capital of Europa, arguably of the world. Since almost everything in the city is within 15 minutes of biking, and going by car will take longer, nowhere in Europe the uptake of cycling as primary mode of transportation is higher.

The city has limited options for extension, since it is bordered by Natura2000 areas, lakes and waterways. The neighbouring municipalities that are predominantly rural.

The municipality is more than the city alone. Through mergers with surrounding former municipalities, it also has the villages of Hoogkerk, Haren, Ten Boer and Ten Post and some 17 smaller villages and hamlets. These villages are suburban (Haren, Hoogkerk) and rural (Ten Boer, Ten Post) in character. Especially the eastern part of Groningen, towards Ten Boer, is agricultural.

The municipal bureau of research and statistics has an excellent website covering the key-statistics of Groningen (https://oisgroningen.nl/cijfers/statistische-informatie).

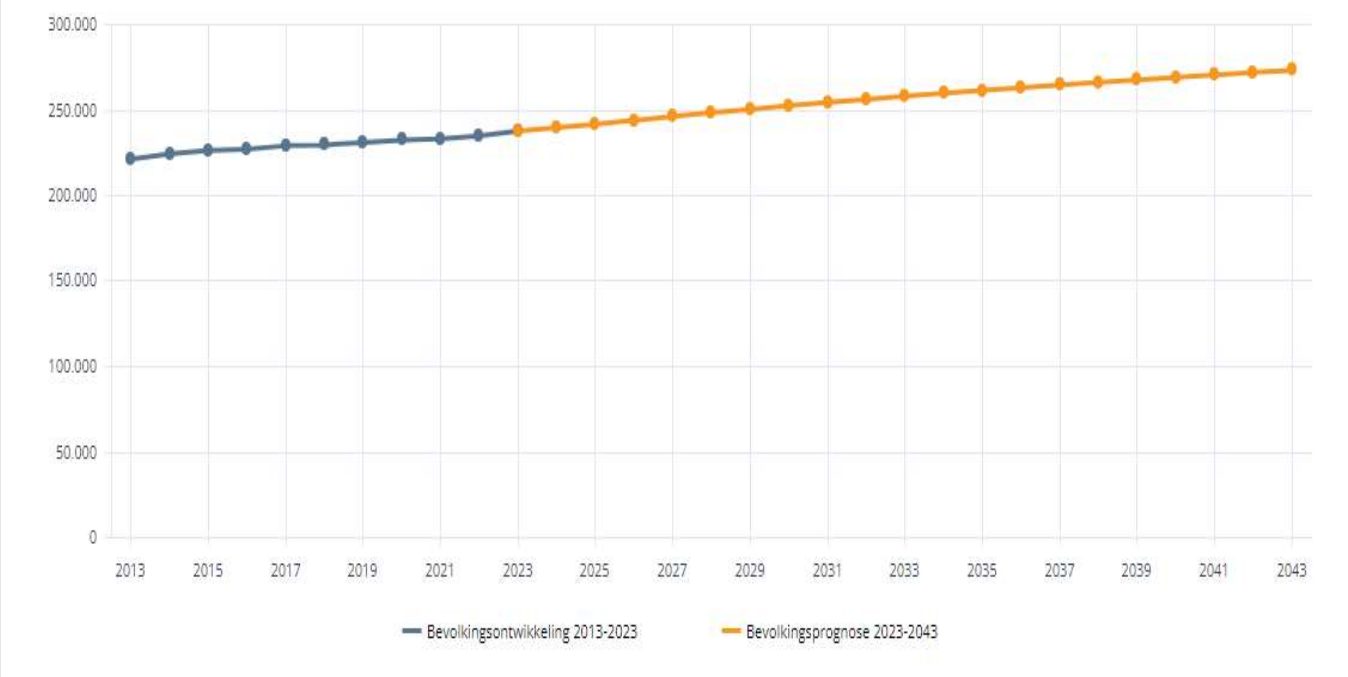


Figure 3 Population development Groningen

Figure 4 development of households in Groningen

Figure 5 Traffic statistics within the city limits of Groningen

Table 1 Key figures Groningen

USE OF LAND

January 1st	2000	2018	2020
Area in hectares	8.369	10.177	19.796
of which built-on	2.960	.	4.038
other land	5.055	.	14.568
water	354	658	1.190

Source: CBS

SOCIAL SECURITY AND INCOME

January 1st	2022	2023	2024
Persons receiving social security	9.790	9.380	9.390
Average spendable income(euro)	2021		2021
Per capita	31.400	Netherlands:	34.300
Per household	42.000		49.500

Source: CBS, SOZAWE

POPULATION

Januari 1st	2022	2023	2024
Number of inhabitants			
0 -17 years	34.076	34.313	34.187
18-26 years	56.400	57.099	61.068
27-64 years	108.582	110.026	111.177
65 +	35.836	36.632	37.395
Male	116.876	118.174	120.954
Female	118.040	119.895	122.865
Total	234.916	238.070	243.827
Average age	38,1	38,1	37,9

Source: municipality of Groningen

EDUCATION

Scholastic year/academic year	'21 -'22	'22-'23	'23-'24
Number of pupils/students			
Primary education	14.305	14.278	14.128
Special education	2.216	2.143	2.111
Junior vocational training	15.993	16.224	16.212
Senior vocational training	21.413	20.136	.
Universities of applied sciences	31.344	30.303	29.027
University education	35.500	34.859	34.236
Of which foreign students	12.341	12.779	12.737

Source: DUO, educational institutions

HOUSEHOLD COMPOSITION

January 1st	2023	2024
One person household	45.711	46.499
One person household, yougsters	11.213	10.674
One person household, more in one house	27.586	32.342
Couple without child(ren)	23.823	24.233
Couple, younsters	6.606	6.652
Couple with child(ren)	18.831	18.734
Single parent family	7.511	7.505
Other	560	566
Total	141.841	147.205

Source: CBS

CULTURE AND LEISURE

Number of visitors	2019	2021	2022
Theatres Schouwburg, Oosterpoo	305.500	76.000	
Forum Groningen		1.279.300	2.089.400
Cinemas	884.000	347.000	569.000
Museums	403.100	154.200	241.600
Botanical garden, Haren	26.700	33.000	36.000
Festival 'Noorderzon'	150.000	.	140.000
Martinichurch	16.000	4.000	10.000
Swimming pools, sportscenter			
Kardinge	636.300	360.000*	
Tourist overnight stays	613.000	429.900	632.800

Source: VVV, NVBF, municipality of Groningen

**refers to 2020*

HOUSING AND OTHER BUILDINGS

January 1st	2014	2015	2024
Dwellings	119.164	119.668	122.866
Houseboats	595	596	596
Mobile homes (locations)	224	225	230
Other buildings	15.441	15.614	15.718
Total	135.424	136.103	139.410

Source: municipality of Groningen

SOLAR PANELS

numbers	2019	2020	2021
Roofs with solar panels	16.273	21.183	27.274
Number of panels on a roof	313.000	377.300	474.200
Number of panels in solar parks	144.870	144.870	215.270
Total solar panels	457.870	522.170	689.470

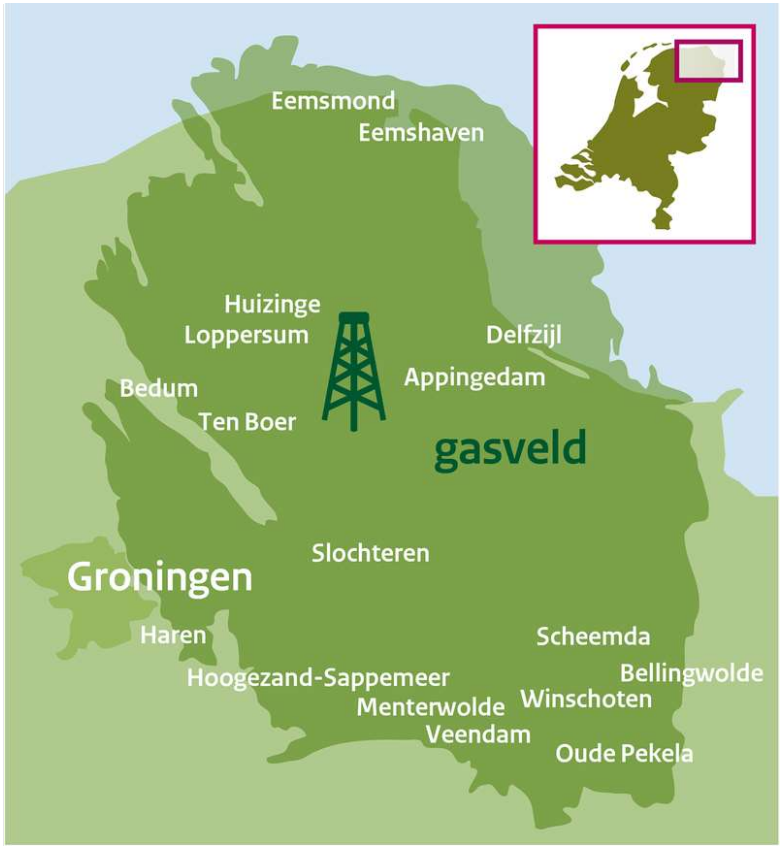
Source: municipality of Groningen

3.2 Energetic history

Groningen has always been connected to energy. Firstly, in ancient times, through peat trading. The Groningen harbour made it possible to transport peat from the eastern and

western parts of the province to its trade partners, in Germany and Holland (Groningen is a Hanze-city).

But all changed on May 29th, 1959. In nearby Slochteren, just 25km from the city, Europe's largest gas field (and one of the largest natural gas fields in the world) was discovered (2.740 billion m3). This discovery literally changed the Netherlands and many European countries.



Source: wikipedia

Figure 6 The Groningen gas field

Natural gas was cheap, relatively clean, and easily transportable. Within 10 years, almost the whole of the Netherlands converted to gas for heating and cooking, and it formed the base of large industrial development. Looking at the official European statistics, Groningen was the third richest region after the City of London and the Greater Paris region. But the statistics were deceptive: though the production was in Groningen, and counted for our BRP, the actual profits went to Shell, Exxon and the National government. Groningen remained an economically underdeveloped area, by Dutch standards. The earnings of gas mining by the national; government were used to increase socio-economic stability in the Netherlands and is a direct cause of the high

levels of welfare in our country. This is also known as the Dutch disease: we spent our natural resources, instead of investing it in a revolving fund.

However, the gas mining turned out to have unwanted side-effects. The almost unlimited pumping out of gas caused the subsurface to compact, with shallow earthquakes (typically at 3000m depth) as a result. These earthquakes were initially denied and down-played by the oil companies and the Dutch government, but a 3,6 Magnitude earthquake near the hamlet of Huizinge was a turning point: there was no denying the causality between gas mining and earthquakes. Hundreds of minor earthquakes followed until today. Widespread damage to buildings was the consequence, though nobody died or was injured through a direct consequence of these quakes. Many homes need rebuilding and reinforcement to be considered safe.

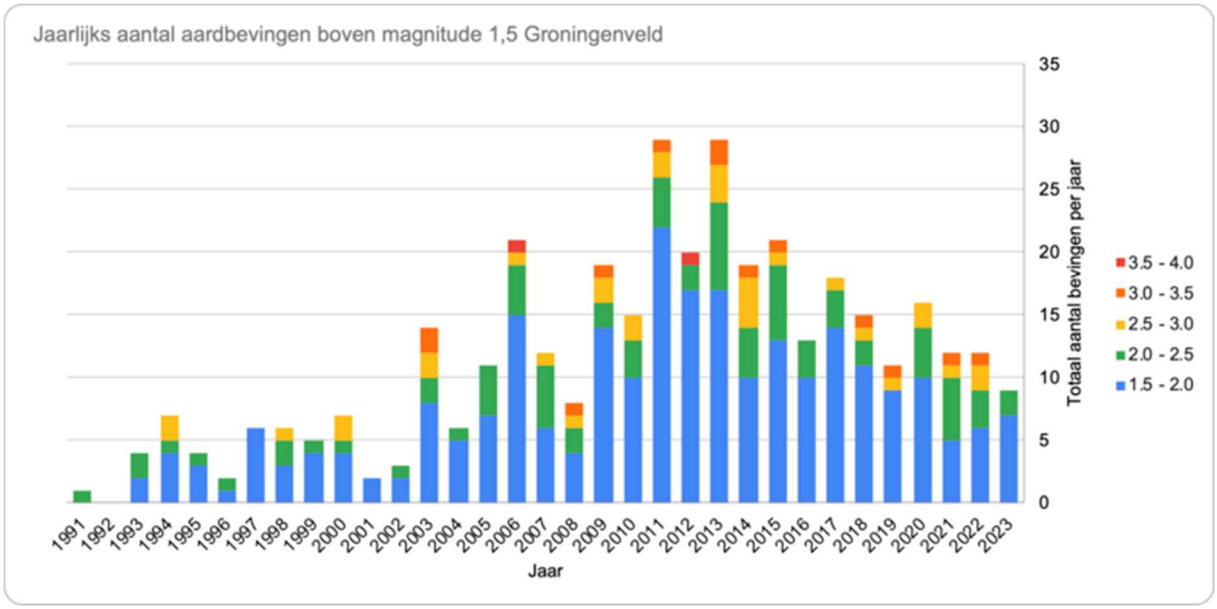


Figure 7 occurrence of earthquakes due to gas mining

The reaction of the Dutch government was a national source of shame. After many years of denying, in 2012 the causality and liability were acknowledged. However, the government upped the output of gas mining to record heights, trying to maximize profit while it lasted. Though liability was accepted, the burden of proof of causality, which is very difficult, was placed at the side of the victims.

This led to uncharacteristic loud and hard protests from the regional population. Finally, the message was understood by The Hague, and gas mining was decreased, the burden of proof was reversed. However, bureaucracy and delay tactics from the oil companies had made an impossible tangle of rules, regulations, models and organizations, which led to a standstill in the compensation and rebuilding of the region.

Only in the last few years, after a parliamentary investigation, has the national government accepted the blame for this mess. Just this spring, it has been decided to stop gas mining altogether. There are many compensation schemes for the inhabitants of the region (13 municipalities including Groningen), a compensation fund for Groningen has been founded, but the scars are visible in the landscape and in the minds of the inhabitants. The trust in the national and regional government is extremely low, the trust in the municipalities is somewhat higher.

Source: ANP

Figure 8 temporary reinforcement for earthquake damage

Many of the characteristic and historic villages in the region are severely impacted. Complete neighbourhoods have to be rebuilt. The inhabitants have to be moved temporarily to newly built 'exchange housing' neighbourhoods next to the villages, where they have to wait months to years on the reconstruction of their homes and properties. The scale of this is immense, in one of the villages of the municipality, Lellens, all homes had to be strengthened. Other villages, such as Overschild, face a complete reconstruction, where most houses are demolished completely and replaced by new homes, thus destroying heritage.

The Groningen region can also be described as the electric generator of the Netherlands. The largest (still fossil fueled) power plant is in the seaport of Groningen, Eemshaven. Electric connections to Norway land in this harbour, it is a node in system of off-shore wind-power and Groningen is key in the transport of electric energy to the rest of the Netherlands and even Germany. It is also a large land-based cluster of wind power. The concentration of energy-intensive industry in the seaport poses an opportunity for the use of residual heat, a pipeline from the port to the city (some 40km) is being researched.

Source: wikipedia

Figure 9 RWE power plant Eemshaven

The focus of Groningen on energy also poses opportunities. The region is home to a large amount of knowledge in the field of energy, gas and energy management. The universities are world class in educating people from around the world in energy-sciences. The energy-related economy is sizable. The transition towards a sustainable energy system has been embraced by the knowledge institutions and the companies. Groningen minted the terms ‘Energy Valley’ (in the 2000’s) and Hydrogen Valley (from 2018 onwards), showcasing that the possibilities for a sustainable energy-economy are optimal in the region.

4 Part A – Current State of Climate Action

Part A "Current State of Climate Action" describes the point of departure of the city towards climate neutrality, including commitments and strategies of key local businesses, and informs the subsequent modules and the outlined pathways to accelerated climate action.

4.1 Scope of climate neutrality

Table 2 Scope of climate neutrality target

Table I-1.1: Climate Neutrality Target by 2035

Sectors	Scope 1	Scope 2	Scope 3
Energy systems	Included	includes	Optional information
Mobility	Included	Included	Optional information
Built environment	included	included	
Industry (including household waste)	included	included	
Agriculture and land use	included	included	Optional information
Geographical boundary	**Same as city administrative boundary**		

Energy systems include the electric system, from source to destination and in the future also the distribution of heat. In the tables of the inventory this is also noted as electricity.

Mobility includes all usage of fuels and electricity for transportation in our municipality, including public transport and transit. Air travel is excluded as the Groningen Airport Eelde is not located within the municipal boundaries.

Built environment is the emissions from for heating, cooling and using buildings, both residential and not residential, such as offices. This does not include industrial processes in these buildings.

Industry refers to the emissions from industrial processes. These may include other GHG's than CO2. In this category, the emissions and negative emissions of processing our domestic waste is also included. Groningen Seaports and its industrial complex is excluded, as it is not within the administrative boundaries of the municipality.

Agriculture and land use is in Groningen mostly the emissions due to agriculture. In this sector other GHG's, such as methane, play an important role.

4.2 Greenhouse Gas Emissions Baseline Inventory

The Baseline inventory of greenhouse gas (GHG) emissions in Groningen has been performed by Berenschot, commissioned by the Groningen Municipality. This inventory is calculating the historic emissions of all GHG and modelling them into Ktons of CO2 equivalent emissions.

The full and most recent emissions inventory can be found online:

https://berenschot-platforms.azurewebsites.net/klimaatdashboard/

Username: Groningen

Password: GroningenBRK2022

For a detailed description of the method see:
https://www.berenschot.nl/media/3j1e0fqo/berenschot-regionale-CO2-routekaart-verantwoording-aanpak-v2021-06112023.pdf

The GHGs included in this inventory are:

- CO2
- Methane
- Nitrous Oxide (N_2O_2)
- HFK-134a, HFK-32, Hfk-125, HFK-143a, HFK-23, HFK-152a
- PFK-116, PFK-14, other PFK's
- Sulphur Hexa Fluoride (SF6)

Table 3 Historic emissions scope 1 and scope 2 of GHG for Groningen (KgCO2 equivalent)

Source: Monitor broeikasgasuitstoot* gemeente Groningen, Berenschot, Sept 18th 2023

	1990	***1995***	***2000***	***2005***	***2010***	***2015***	***2020***
Electricity	443.714.874	498.263.306	517.349.890	491.278.146	499.565.482	535.942.373	319.939.223
Build environment	394.486.541	436.843.994	426.962.556	413.627.124	484.324.356	381.291.743	327.066.413
Industry	664.039.518	470.916.180	384.324.158	343.589.518	365.053.464	273.767.205	238.499.012
Agriculture and land use	130.058.380	128.924.606	116.599.351	105.069.573	116.859.607	119.427.713	117.327.793
Mobility	311.335.129	321.987.377	340.326.324	344.973.197	288.200.578	296.161.827	286.416.043
Grand Total	**1.943.634.442**	**1.856.935.463**	**1.785.562.279**	**1.698.537.557**	**1.754.003.486**	**1.606.590.861**	**1.289.248.484**

Table 4 percentual division between sectors

% of GHG emissions	Sum of 1990	Sum of 1995	Sum of 2000	Sum of 2005	Sum of 2010	Sum of 2015	Sum of 2020
Electricity	23%	27%	29%	29%	28%	33%	25%
Built environment	20%	24%	24%	24%	28%	24%	25%
Industry	34%	25%	22%	20%	21%	17%	18%
Agriculture and land use	7%	7%	7%	6%	7%	7%	9%
Mobility	16%	17%	19%	20%	16%	18%	22%
Grand Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 5 Historic reductions in percentages

%reduction vs 1990	Sum of 1990	Sum of 1995	Sum of 2000	Sum of 2005	Sum of 2010	Sum of 2015	Sum of 2020
Electricity	0%	-12%	-17%	-11%	-13%	-21%	28%
Built environment	0%	-11%	-8%	-5%	-23%	3%	17%
Industry	0%	29%	42%	48%	45%	59%	64%
Agriculture and land use	0%	1%	10%	19%	10%	8%	10%
Mobility	0%	-3%	-9%	-11%	7%	5%	8%
Grand Total	**0%**	**4%**	**8%**	**13%**	**10%**	**17%**	**34%**

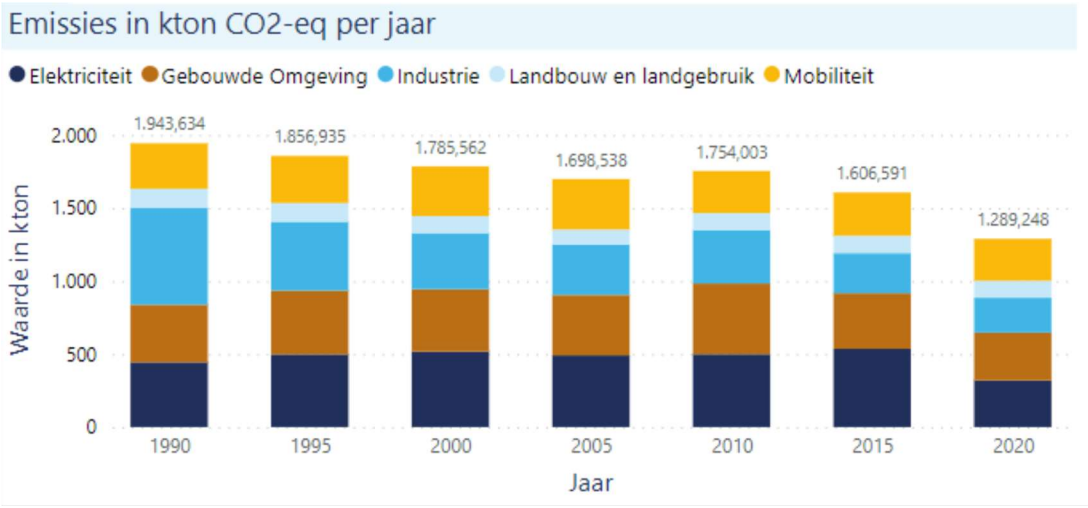


Figure 10 Graph Historic emissions

Figure 11 Graph Reductions per sector

Figure 12 Emissions per GHG

4.3 Current Policies and Strategies Assessment

The chapters on European and national policies are based on the work of David Dooghe (TNO and NZC), for which we are grateful!

4.3.1 European policies

At EU and national level, we want to highlight the 2019 European Green Deal, the 2018 National Climate Agreement and the 2021 Dutch Coalition Agreement 2021-2025. The Green Deal delivers a package of policy proposals for reducing net GHG emissions by at least 55% by 2030 and in the Agreement the Dutch government and national stakeholders committed to bring national CO2 emissions down by at least 49% by 2030 and 95% by 2050 compared to 1990. In the Dutch Coalition Agreement 2021-2025, the national government increased this goal to at least 55%, but aiming 60% in 2030. A new cabinet has started on July 2nd, 2024, and its exact climate policies will be fleshed out in the coming months.

The 2050 goal of the Green Deal, the Climate or Coalition Agreement has influenced other EU or national policies and projects: e.g. the EU Climate Law, the Dutch Energy Agenda and Mobility Vision. Although we commend this European Green Deal National Climate Agreement, as it supports Dutch municipalities to become climate neutral, at the same time the 2050 (almost) climate neutral goal of the national government creates barriers for all Dutch Mission Cities, which have a target that is decades ahead. These barriers are further described in chapter 8.5.4

A-2.1.1: List of relevant international/European policies, strategies & regulations							
Type	Name & Title	Year of Publication	Emission domain(s)	Description	Relevance for/ impact on Local Action	Stakeholders	Need for action
regulation/ policy/ strategy/ action plan	Name of policy/ strategy/ plans)			Description of policy/ strategy/ plans)			
United Nations Treaty	Paris Agreement	2015	All	Treaty signed by 196 UN parties to goal is to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels."	High relevance/ indirect impact	All	Framework for most actions in this list.

EU Policy	EU Emissions Trading System	2005	All	System based on the 'cap and trade' principle. A cap is a limit set on the total amount of GHG that can be emitted by the sectors covered by the system. The cap is reduced annually in line with the EU's climate target. The scope (which sectors are included) expands over time, with the maritime sector being the latest addition (2024).	Medium relevance / indirect impact	Energy sector, industry, building sector and road transport	EU-policy to reduce emissions. Link with all missions/actions aimed at reducing CO2
EU Policy	European Green Deal	2019	All	Package of policy proposals for reducing net GHG emissions by at least 55% by 2030.	High relevance / indirect impact	Governments, production industry, consumers.	The European Green Deal (europa.eu). Link with all missions/ actions aimed at reducing CO2
EU Policy	EU Climate Law	2020	All	European Union commitment for the target to be climate neutral by 2050 with identified 2030 target and pathway	High relevance / indirect impact	All	Making the EU climate-neutral by 2050 (europa.eu)

				proposals to reach both targets.			
EU Regulation	TEN-T policy	2013	Mobility	To support the transition to a cleaner, greener and smarter mobility the Commission revised the TEN-T Regulation of 2013. The revised TEN-T Regulation should put the transport sector on track to cut its emissions by 90%. It responds to the need to increase connectivity across Europe and to shift more passengers and freight to the sustainable modes of transport.	Medium relevance / indirect impact	Local and regional government.	Establishment of local SUMP and development of indicators
EU Regulation	Alternative fuels infrastructure regulation (AFIR)	2021	Mobility	2025-2030 deployment targets for recharging and refuelling stations for alternative	Medium relevance / indirect impact	Energy providers, network providers, drivers,	Placing sufficient number of charging stations for trucks, also in urban areas

				fuels (to fossil fuels)		transportation sector.	
EU Regulation	Regulation 2023/851 Actualised CO2 emission standards performance standards for cars and vans	1992-present	Mobility, built environment	Introducing stricter CO2 emissions targets for cars and vans in line with the EU reduction targets for cars and vans of 100% by 2035.	High relevance / direct impact	Industry, transport sector, consumers	Link with action plan air quality, link with local mobility vision and implementation
EU Regulation	Actualised CO2 emission standards performance standards for heavy-duty vehicles	1992-present	Mobility, built environment	Introducing stricter CO2 emissions targets for heavy-duty vehicles in line with the EU reduction targets for cars and vans of 100% by 2035.	High relevance / direct impact	Industry, transport sector	Link with action plan air quality, link with local mobility vision and implementation
EU Action Plan	Circular Economy Action Plan	2020	Circular economy	Action plan with measures to produce more sustainable products, decrease waste and promote circularity in the EU. Part of European Green Deal.	High relevance/direct impact	Governments, production industry, consumers.	Link with missions on circular and sustainable inner cities, neighborhoods and businesses

EU Strategy	EU Biodiversity strategy 2050	2020	Built environment	EU Strategy to halt the decline of biodiversity and help biodiversity increase by 2030. Part of European Green Deal.	Medium relevance / indirect impact	Governments, developers, housing associations	Link with missions/ actions on green and water as a base
EU Policy	EU Nature Restoration Law	2023	Built environment, circular economy	Set of rules to restore biodiversity and ecosystems within the EU aiming to have at least 20% of EU's land and sea covered by recovery measures by 2030 and all ecosystems by 2050.	Medium relevance / indirect impact	Governments, agricultural sector, heavy industry, EU residents.	Link with missions/ actions on green and water as a base
EU Action Plan	Zero Pollution Action Plan	2021	All	Action plan to drastically decrease pollution within the EU. Target of zero pollution in 2050 and 25-55% percent decreases in different types of pollution by 2030.	Medium relevance / indirect impact	Governments, industrial polluters, transportation sector, residents of the EU.	

EU Regulation	Energy Efficiency Directive (EED	2012 - present	Built environment,	Setting rules and obligations for achieving the EU's ambitious energy efficiency targets. The revised Energy Efficiency Directive establishes "energy efficiency first" as a fundamental principal of EU energy policy, giving it legal standing for the first time.	High relevance/ direct impact	All	Obligatory four yearly audit, although we now are getting certified for the CO2 Performance ladder we will be exempt as the CO2 Performance ladder is more strict on the subject.
EU Regulation	Clean Vehicles Directive (CVD)	2019 - present	Mobility	Purpose of the CVD is to increase the market for clean and energy efficient vehicles by promoting them through procurement by obliging the contracting authorities to fulfil a certain minimum percentage of clean and zero emission vehicles in their fleet	High relevance / direct impact	Government	

4.3.2 Policies on National Level

A-2.1.2: List of relevant national and provincial policies, strategies & regulations							
Type	Name & Title	Year of Publication	Emission domain(s)	Description	Relevance for/ impact on Local Action	Stakeholders	Need for action
(regulation/ policy/ strategy/ action plan	(Name of policy/ strategy/ plans)			(Description of policy/ strategy/ plans)			
Policy	National Climate Agreement	2018	All	Agreement between large group of national stakeholders committing to bringing national CO2 emissions down by at least 49% by 2030 and 95% by 2050 compared to 1990	High relevance / direct impact	All	Framework for most actions in this list. Also, a framework on which municipalities get national funding for implementation of plans in the National Climate Agreement.
Strategy	Energy Agenda	2016	All	The main lines of future energy policy for the period up to 2050.		All	Link with local missions on speeding up energy saving, insulating and renewable energy.

Strategy	National Approach Mobility Transition	Multi-year approach	Mobility	Accelerating the mobility transition through a joint approach by all governments.	Medium relevance / indirect impact	Ministry of Infrastructure, provinces and municipalities	Measures aimed at structurally improving mobility. Link with local mobility vision and implementation.
Vision paper	Mobility vision 2050	2023	Mobility	National vision paper about the future of mobility	Medium relevance / indirect impact	All	Framework for policies on mobility.
Policy proposal	Wetsvoorstel Collectieve Warmte	2022	Energy Transition	Proposed bill to facilitate the development of district heating by designating public parties to develop said networks, thus giving the public sector more control.	High relevance / direct impact	Governments (all levels) , energy suppliers, housing associations, residents	Framework for developing district heating.
Action plan	National Insulation Program	2022	Energy transition	National program to accelerate insulation among households, this to decrease energy consumption and prepare for non-fossil fuel heating sources in 2.5 million households by 2030.	High relevance / direct impact	Governments, housing associations, homeowners, insulation companies , occupants of housing needing insulation.	Link with local missions on speeding up energy saving and insulating. Nationaal Isolatieprogramma

Program	Building Balance	Multi-year approach	Buildings, homes, industry	Initiating, encouraging and supporting independent regional and national chains for biobased building.		Farmers, producers, builders, government, homeowners	Link with all missions/ actions to speed up existing policies. Bouwmaterialen van eigen bodem - Building Balance
Action Plan	Provincial multiple year plan on infrastructure, energy and climate (pMIEK)	2023	Energy transition, built environment	Integrated provincial analysis on the most important decisions to make to ensure a functioning energy system beyond 2030.	High relevance/direct impact	Municipalities, network operators, province	Framework for development energy infrastructure on a provincial level, in accordance with municipalities. Reiterated every other year.
Action Plan	Delta Plan on Spatial Adaptation (National)	2018	Built environment, rural areas	Limit flooding, heat stress, drought and the consequences of flooding.		All	Link with missions/ actions on green, water and climate proof as a base. Deltaplan Ruimtelijke adaptatie | Drie thema's | Deltaprogramma

Action Plan	Operatie Steenbreek	Multi-year approach	Built environment, public space	National knowledge and network organization that provides support in sustainably greening our living environment.		Municipalities, provinces, water boards, project developers, housing associations, knowledge and educational institutions and other social organizations.	Link with missions/ actions to speed up existing policies regarding green, water and climate proof as a base. Stichting Steenbreek I Samen van verstening naar vergroening
Policy	National Performance Agreements (NPA) Housing Associations	2023	Energy transition, built environment	Agreements that state that housing associations will phase out the EFG labels in all their social housing stock by 2028 at the latest. In order to achieve the objectives of the NPA, a further acceleration in efforts is needed.	High relevance / direct impact	Housing Associations, Renters	Link with local missions on speeding up energy saving and insulating.

Regulation	Wet personenvervoer (Wp2000)	2001	Sustainable Mobility	Regulation to increase efficiency and cost-effectivity of local and regional public transportation. Also states that public transportation providers can allocate funds to shared mobility solutions.	Medium relevance / indirect impact	Governments, public transportation providers	Affects decisions by local and regional public transport providers.
Policy	Policy on Charging Infrastructure for Electric Vehicles/ Beleid oplaadinfrastructuur elektrische voertuigen	2022	Sustainable Mobility, Energy Transition	The National approach on charging infrastructure aims to make all transport emission free by 2050. That can only be achieved by having a good and national covering network.	High relevance / direct impact	Governments, energy providers, public transportation provider HTM, energy grid manager, logistic businesses, drivers	

Regulation	Manifest Maatschappelijk Verantwoord Opdrachtgeven en Inkopen (MVOI)/ Action plan sustainable commissioning and procuremen	2022	All	Manifest signed by 90 (semi)governmental organisations in order to stimulate ambitious social commissioning and sustainable procurement. Participation is optional, and still parties are joining and committing to writing an Action Plan. It is divided in the themes; environment and biodiversity, climate, cicularity, Internatioanl Social Conditions (ISV or chain responsibility), diversity and inclusion and social return.	High relevance / direct impact	All	Framework for municipal Actionplan MVOI
Strategy / Vision	National plan energysystem	2023	Energy transition, built environment	Concept vision for the National Energysystem in 2050	High relevance / direct impact	Governments, energy providers, all building owners	Framework for other integral approaches to energy infrastructure such as the pMIEK.

Program	Dutch Metropolitan Innovations (DMI)	2023	Mobilty, built environment	The Dutch Metropolitan Innovations (ecosystem provides the domains of mobility, public space and housing with new tools from the digital world. It is aimed at coordinating policy and investments – both between governments and between governments and between governments and businesses.			
Program	Nationaal Programma Lokale Warmtetransitie/ National local heat transition program		Energy transition, built environment	The National Local Heat Transition Program supports municipalities in the heat transition with information practical examples and tools			
Law	Wet Financiering decentrale overheden / Law financing of decentralised governments	2013		Law on standards for risk management in raising finance (borrowing) and in deploying			

				funds (investing)			

4.3.3 Regional Policies

All Dutch Regions are required to have a Regional Energy Strategy (RES). The Groningen region coincides with the administrative borders of the province of Groningen. The full RES (1.0) can be found online:

https://resgroningen.nl/over+de+res/achtergrondinformatie/handlerdownloadfiles.ashx?idnv=1990181

An update on the progress of the RES (Version 2.0) can be found here:

https://www.resgroningen.nl/over+de+res/achtergrondinformatie/handlerdownloadfiles.ashx?idnv=2467068

The main commitment of the RES is to generate 5,7TWh of renewable electricity in 2030 (solar,>15kWp and wind). This translates for the Municipality of Groningen to 0,5TWh. The RES translates the commitment of 5,7TWh also in terms of expected economic value: 26.000 labour years in 2030, and 375 fulltime jobs for exploitation and maintenance.

Specific for the Groningen region is the National Program Groningen (NPG) which, though formally at national level, is in essence a regional program. It was formed to provide a structure for regional development and compensation of the consequences of gas mining. The most important part of this program is 'Nij Begun" ('a New Beginning' in local Groningen language), which will give a boost compensation of damages, to sustainability, to economic and to cultural development.

For the climate mitigation of the region (this includes the municipalities in the earthquake-zone, the 10 municipalities in the province of Groningen and 3 municipalities in the province of Drenthe), the so-called measures 28 and 29 are extremely important. These measures target to isolate all homes in the region before 2035. For these measures €1.6 Billion (investment in materials) has been reserved, along with €1 Billion for execution of the subsidy program.

Measure 28: all homes that need to be reinforced (major reinforcement with a rebuilding schedule of more than 4 months), will be turn-key and completely retrofitted to isolation-standard (47Kw/m2), all paid for by the national government.

Measure 29:

- *all homeowners with a light reinforcement regiment of their homes, or all homeowners who already have had their homes reinforced, will get 100% subsidy on retrofitting of isolation and ventilation, with a maximum of € 40.000.*
- *Homeowners with an income of maximum 140% of the minimum wages will be eligible for a subsidy of 100% with a of maximum €40.000*
- *All other homeowners in the region will be eligible for a 50% subsidy with a maximum of € 20.000.*

The impact of these measures is large, not only in terms of reduction of energy consumption, but also in terms of economy and logistics. The scale of this operation is huge. Local retrofitting and construction companies will be able to fulfil an estimated 15% of all demand. This may lead to an increase in the price for labour and materials. To avoid that village will be unreachable by the sheer amount of building traffic, a coordinated and phased approach will be necessary.

4.3.4 Local policies

Groningen has a had energy-related policies since 2004. Currently, there may be more than 30 policy documents describing policies, strategies and actions related to climate mitigation and climate adaptation. For the Horizon funded project 'Making City', an analysis of the Groningen policy-framework was done by Merijn van Geet et al. Though the analysis is from 2023 and some of the policies referred have been renewed or are in the process of renewal, the general analysis and the conclusions are valid and valuable.

> *"In general, policy development in Groningen follows the lines of 10 specific policy areas for which Dutch local governments have different formal responsibilities, and along which budget plans are developed. Table [...] lists these policy areas and sets out the underlying policy topics that government action in Groningen is targeting. Efforts to promote the energy transition in Groningen are considered in several of these policy areas. The analysis of existing policies showed that explicit references to the energy transition are made in the policy areas of Economy and Employment, Traffic, Housing and Quality Living Environment. These policy areas are therefore analysed in more detail below to show how links are made to the local energy transition within each of these policy areas.*
>
> *A quick scan of all policies within the areas of Economy and Employment, Traffic, Housing and Quality Living Environment reveals that, overall, the current body adopted of policies can be divided in two categories. Policies are either more strategic-oriented, focussing on the medium-term [...] or they are more operational oriented, focussing on the short-term [...]. The scope of strategic policies range between 2025, 2030 and 2035. Furthermore, they are characterized by a medium level of abstraction as they lay out general plans, approaches, principles, or strategies on how to address certain policy challenges. These strategic policies often provide the foundation for the more operational oriented policies. These operational policy frameworks are of a low level of abstraction as the define specific actions, project or investments to be made within the coming 2-5 years. The strategic policies [...] are therefore strongly interrelated. Operational policy frameworks often provide further substantiation of strategic plans or approaches in the form of specific on-the-ground measures."*

Notable is that ‘energy-transition' is the context of the analysis, and of the policies in general. With notable exception of the ‘Roadmap CO2 neutral 2035’ climate mitigation or reduction of emissions of GHG is not noted as the main goal of the policies. Though Groningen is signatory of the Covenant of Mayors since 2017, it has not a Sustainable Energy and Climate Action Plan (SECAP), but rather a collection of plans regarding energy and climate action.

Table 6 Main policy areas within the municipality of Groningen

Policy domains of the Municipality of Groningen and its link to the energy transition

Policy areas of Groningen	**Underlying policy topics**	**Includes policy on the energy transition**
1.Work and Income	Jobs, labour market participation, social participation, social security benefits, poverty, debt counselling.	Yes
2. Economy and Employment	Economy, partnerships with knowledge institutes, knowledge and innovation, promoting knowledge sector, matching talent to businesses, knowledge economy, local entrepreneurs, tourism, city centre development, retail outside the city centre, markets, business activity, business locations, start-ups, trade relationships.	Yes
3. Education	Education opportunities and quality, education for adults, locations for education, talent development, compulsory education, transport for schoolchildren, special education.	Yes
4. Wellbeing, Health and Healthcare	Citizen initiatives, active citizenship, social cohesion, liveability in neighbourhoods, diversity, integration, emancipation, local public health, social services, special healthcare, domestic violence, refugees.	No

5. Sport and Education	Sport clubs, sport facilities, sport in public space, youth and sport, talents.	No
6. Culture	Cultural talent, events, accessibility to culture, diverse cultural offer, cultural education.	No
7. Traffic	Cycling, cycling infrastructure, accessibility, public transport, car traffic, parking, road traffic safety.	Yes
8. Housing	Urban development, student housing, rental policy, housing for the elderly, special housing, care housing, housing affordability and accessibility, housing stock quality, cultural history, archaeology, monuments, energy neutral housing, neighbourhood renewal, houseboats.	Yes
9. Quality Living Environment	Maintenance of public space, clean living environment, sewage and water, waste management, living quality, citizen participation, burials, animal welfare, health and safety, spatial quality.	Yes
10. Safety	Violence, burglary, domestic nuisance, safe entrepreneurship, radicalization, alcohol and drugs, problematic youth, youth and safety, human trafficking, prostitution, motor gangs, organized crime, integrity and safety, physical safety, external safety, earthquakes.	No

Table 7 main strategic/medium-term policy-documents related to climate-mitigation and –adaptation

Plan and period	*description*	*Generic goals*
Spatial Vision ' Levende ruimte 2022-2035'	Strategic vision for the city of Groningen, integral vision on urban development	• Facilitate growth to 250,000 inhabitants • 20.000 new dwellings • 15,000 new jobs

	(housing, work, mobility, energy, social)	• Achieve a climate neutral and gas-free building stock in 2035 • Promote the energy transition with solar parks on land, large wind turbines on see, and locally supported wind energy projects close to the city • Support cycling and walking as means of transport • Promote public transport as an attractive alternative to the car • Emission-free mobility in city centre • Improve social inclusion
Road map Groningen CO2 Neutral 2035: 2018-2035	Policy on making Groningen CO2 neutral. The document contains specific goals on housing, businesses, industry, mobility and RES generation. The medium-term goals for 2035 are mentioned here.	• All energy from renewable sources • Generate as much of the energy demand as possible on municipal territory • Housing: reduce heat demand by 20% through insulation, generate 200MWp of solar energy on dwellings, 50% of dwellings have a solar boiler, 35% of dwellings connected to heat grid, 50% of dwellings have a heat pump • Businesses: reduce heat demand by 30% through insulation, generate 200MWp of solar energy on businesses, connect 30% of SMB to heat grid and 50% Seasonal Thermal Energy Storage. • Industry: offices have a A++ energy label, heat demand for industry is 50% electrical and 25% with biomass (the latter does not apply for the food and paper

		industry), 1% efficiency improvement is realised each year. • Mobility: 90% of vehicles run on renewable energy, public bus transport is emission-free, freight transport is CO2 neutral. • RES generation: 500 MWp generated by solar parks, 36MWp generated by wind on land, 100% biofuels, geothermal energy as source for heat grid.
Heat transition vision: 2019-2035	Presents a strategy and approach to disconnect all neighbourhoods from the gas network and providing alternative means for heating 2035	• Adopt a neighbourhood-oriented approach which comprises of 4 components; i) Neighbourhood energy vision, ii) Neighbourhood energy plan, iii) Neighbourhood energy action plan, iv) implementation. • Three scenarios for achieving heat: connect to a heat grid, 100% electric, hybrid. • The neighbourhoods Reitdiep, Paddepoel and Noorderplantsoenbuurt, which form a representative sample for the city, will be used to develop experience with the neighbourhood energy approach.
Living Quality Public Space Guideline: 2021 onwards	This vision provides a strategic account on how Groningen will address the housing challenges within the municipality.	• Meet growing housing demand in all segments • Develop new mechanisms for influencing the housing market • Maintain living quality in the face rapid urban growth

		• Develop beautiful, sustainable, energy efficient and energy positive neighbourhoods • Prioritize brown-field development • Adhere to compact city principles
Mobility vision "Groningen on the right road' 2021 – 2040	This vision elaborates on the mobility side of The Next City Vision, which revolves around the realization of the 'compact city concept'.	• Absorb the growing mobility that will result from planned urban growth • Reduce space used up by car traffic • Promote 'healthy' and clean forms of mobility • Promote multimodal trip chains and shared mobility solutions • Walking, cycling, public transport when possible and car when necessary.
Green plan Groningen 'vitamine G': 2020-2030	This plan is developed as port of the climate adaptation implementation agenda 2020-2024. The plan is developed based on the ambitions formulated in the 'Next City' strategy and the coalition agreement.	• Develop a robust green network by connecting green areas, by creating a multifunctional green network (for people, plants and animals), by developing green and attractive cycling and walking routes, by developing a network of tree lanes and by formulating a Municipal Ecological Structure. • Create attractive and diverse parks by giving parks their own identity and program, by improving the efficiency of green maintenance, by improving accessibility of green areas and by promoting

		multifunctional use of green areas. • Create healthy residential, work and shopping areas by planting more trees, by creating more biodiversity in built-up area, by greening living areas of vulnerable people, by promoting participation projects, by considering greening in the front-end stage of the policy/project process, by adopting a nature-inclusive building approach and by creating an investment fund for greening • Realize resilient and accessible rural areas by promoting nature inclusive agriculture, by promoting greening in rural areas, by exploiting opportunities for greening or nature within solar or wind park development projects, by optimizing the transition between rural and urban areas.

This table was adopted from Making City City Vision 2050

Of course, this is a snapshot in time of the currently officially adopted policy frameworks. These documents are sometimes in revision. The main document on CO2 reductions, the Roadmap Groningen CO2 neutral 2035 is currently under revision and is expected to be adopted by the city council in autumn 2024.

There are some 30 policy documents with impact on climate mitigation. For a complete list see Appendix A. The main interventions are:

- isolation of all homes

- connecting 40.000 homes to a (sustainable) heat grid, thus decarbonizing them

- local production of wind and solar energy, in local ownership
- abandoning car-logic, designing a city for pedestrians, bikes, public transport and far less (decarbonized) car traffic
- reduction of unusable household waste to zero

Whilst doing so, it is seen as an absolute necessity to make this transformation affordable and accessible for all, eradicating energy poverty. The grand vision is that Groningen will remain one of the best cities in Europe to live, to work and to recreate in, adapted to climate changes, designed for healthy living, with a high degree of equality, and with a sustainable, stable and affordable energy system.

4.3.5 Role of hydrogen

The Groningen region is frontrunner in the development of an energy system that uses hydrogen as bearer of energy. The region is also known as Hydrogen Valley. This position is acknowledged by the European Commission, and several by the EC supported projects are being carried out in the region.

However, hydrogen does not play a significant role in the climate mitigation plans towards 2035. This requires some explanation. Overall, the technological maturity level of hydrogen is still low. The municipality does not expect that before 2035 a large-scale adoption of H2 as energy carrier will take place. The expectation is that hydrogen will be needed in mobility (especially in long haul cargo-logistics) and in industry. These applications do not impact Groningen very much. The use of hydrogen in the Built Environment will probably be very limited, as the production of hydrogen is not very energy efficient.

Groningen sees the development of hydrogen technology as important for the knowledge-based economy in the city. The approach towards H2 in Groningen is therefore more in terms of economic development than based on use in climate mitigation.

4.3.6 Energy storage

If electric energy is scarce in groningen , due to gridlock, it would make sense to store locally produced energy locally, in small batteries at homes (KWh range), or in larger batteries (MWh range) near major users. This could be used for peak-shaving, thus leveraging the efficiency of our local grid.

Alas, it is not as simple as it may look. Home-battery storage is offered, both as a service (a lease-construction) and as products. Economically, these products are not attractive,

the pay-back period is long, as high-capacity batteries are still expensive. Also, home-insurers are not very keen on these batteries, due to perceived fire hazards. For larger scale batteries, a business case could be made.

However, if you look into the business models of the providers, these batteries do not necessarily store locally produced energy. They are managed to store energy at times when the energy prices are low, or even negative. This means that if there is a lot of wind on the North Sea, but not much sun on land, massive amounts of cheap energy need to be transported over the already congested grid. This will lead to even more congestion.

Storage could theoretically mitigate netcongestion, but it all depends on management and timing. Commercial providers do not optimize for minimal net-use, they optimize for maximal profit. Therefore, Groningen does not promote the use of commercially operated electric storage.

The municipality is looking into the possibilities of storing energy in large batteries or even with compressed air technology in old gas-pipes, but then optimized for congestion-mitigation. This will affect the business case negatively, so it is still in study-phase.

4.3.7 Involvement in Projects co-funded by the European Committee

It is not a coincidence that Groningen applied for the Mission 2030: 100 Climate Neutral and Smart Cities. Groningen has an active policy for European involvement and International Affairs. With European projects and partnerships, Groningen wants to accelerate reaching its goals by learning and sharing knowledge with cities and other partners. By aligning its goals with the European goals, Groningen tries to create synergy between European policies, local policies and the policies and knowledge of partners in Europe.

Groningen has defined the following focus points for European cooperation:

- Energy transition
- Hydrogen
- Climate adaptation
- Circular economy
- Quality of life
- Sustainable mobility
- Digital transition

The focus points are all more or less related to climate mitigation and climate adaptation.

For an overview of the most current European funded projects see next table.

Table 8 Overview recent European funded projects

Project	Program	Timeframe	Subsidy by EU	Online resource
Making City – energy efficient pathway for the city transformation	Horizon 2020	Dec 2018 – Dec 2024	€2.700.000	makingcity.eu
EC2 – Building a Low-Carbon, Climate Resilient Future: Secure, Clean and Efficient Energy	Horizon 2020	Jan 2021 – Dec 2023	€ 35.572	EC2project.eu
European City Facility	European City Facility	Spring 2022 – spring 2024	€ 60.000	Eucityfacility.eu
REVIVE (Refuse Vehicle Innovation and Validation in Europe)	: Horizon 2020	Jan 2018 – July 2024	€ 600.000	www.h2revive.eu
HyTrEc2 (Hydrogen Transport Economy for the North Sea Region 2)	Interreg North Sea Region	Oct 2016 – Jun 2023	€ 570.000	https://northsearegion.eu/hytrec2/
Hector (Hydrogen Waste Collection Vehicles in	Interreg North West Europe	Jan 2019 – Dec 2023	€ 660,000	https://vb.nweurope.eu/projects/project-search/hector-hydrogen-waste-collection-vehicles-in-north-west-europe/

North West Europe)				
HEAVENN (Hydrogen Energy Applications for Valley Environments in Northern Netherlands)	Horizon 2020	Jan 2020 – Dec 2025	€ 2.000.000	www.heavenn.org
NL-NASCCELERATE	LIFE	Mar 2023 – Dec 2027	€ 264.215	Julwww.klimaatadaptatienederland.nl/overheden/nas/kennis/aanpak-programma/programma/life-ip-nasccelerate
Cool Square	LIFE	Jul 2021 – Jul 2024	€ 1.031.596	www.ruimtevoorjou.groningen.nl/life-cool-square
Food trails	Horizon 2020	Oct 2020 tot Oct 2024	€ 664.220	: foodtrails.milanurbanfoodpolicy.org
Active Cities	Interreg North Sea Region	Oct 2022 – Dec 2025	€ 279.485,-	https://www.interregnorthsea.eu/active-cities
Surflogh (Smart Urban Freight Logistics Hub)	Interreg North Sea Region	Sep 2017 - Jun 2023	€ 400.000	https://northsearegion.eu/surflogh/
ULaaDS (Urban Logistics as an on Demand Service)		Sep 2020 - Sep 2023	€ 92.500	ulaads.eu
Coding the Curbs	EIT Urban Mobility	Jan 2023 – Dec 2023	€ 23.453	codingthecurbs.com

4.4 Stakeholder analysis

To understand the system of local CO2 emissions, you'll need to know the stakeholders and their roles.

Of course, our energy system is not just local, so obvious stakeholders are the higher levels of government (national government and European Commission), who are responsible for the larger picture.

Locally, we have identified the following stakeholders:

Table 9 Stakeholders

System	Stakeholders	Influence on the city´s climate neutrality ambition	Interest in the city´s climate neutrality ambition
Built environment	municipality	high influence: prime responsibility for climate mitigation and adaptation, responsible for urban planning, subsidizer for mitigating actions, shareholder in het grid	legal obligations, political ambitions to become climate neutral in 2035
	social housing corporations	owner/renter of housing of 31% (2021) of the homes in groningen	legal obligations to reduce energy consumption, voluntary agreement with municipality to reduce energy consumption (masterplan CO2 neutral and natural gas free housing stock Groningen 2019)
	private owner non-rented	possession of 40% of the housing stock	mostly economic motives: reduction of energy bill.
	private landlords	26% of housing stock	economic reasons: regulations will limit rental fees for non-energy efficient houses, value of real estate will be higher after retrofitting
	tenants	57% of housing stock	economic reasons: energy bill
	real estate developers (homes)	new neighbourhoods and renovations	legal obligations to build gas-free and to insulate. Higher sustainability will lead to higher real estate value. Net congestion threatens development

	real estate developers (commercial)	new and renovated commercial real estate	economic reasons: higher property value; regulatory obligations
	commercial real estate owners	commercial real estate	economic reason: higher rental value, higher property value, legal obligations
	commercial real estate tenants	commercial real estate	economic reason: energy bill
	hame owner Associations	managing multi-owner buildings	Economic reasoning, energy bill
Energy systems	municipality	management of public space, local bylaws and regulation, shareholder of heat grid, sole shareholder of municipal electricity company	legal obligations, political ambitions to become climate neutral in 2035
	TenneT	grid owner and management of high voltage grid in the Netherlands, transport of electricity, owner of transformer station in Groningen and owner of high voltage powerlines in Groningen	dimensioning of high voltage grid, modelling central production capacity, supply of stable and ample electricity to the region, all depended on energy system and demand/supply in Groningen
	Enexis	grid owner and management of mid-voltage and end-distribution electric grid in Groningen and region	dimensioning of mid voltage grid, modelling decentral supply and demand, supply of ample and stable electricity, solving gridlock
	Warmtestad	heat grid operator, owned by municipality and local water company	Heat grid is necessary pathway to net zero, in order to phase out natural gas
	local energy cooperatives	provision of sustainable energy	local sustainable sourced energy is necessary pathway to net zero
	solar thermal park Dorkwerd	provision of sustainable heat	for net zero sustainable heat sources are necessary
	industry	provision of residual heat	for net zero sustainable heat sources are necessary
	building owners	provision of (roof mounted) PV electricity	local sustainable sourced energy is necessary pathway to net zero
	province	Zoning and permitting of large PV and wind-power, permitting of High Voltage lines, permitting of infrastructure crossing municipal borders	Legal obligations, political ambitions

	all inhabitants	consumption of energy	reduction of energy use
mobility	municipality	management of public space and roads, shareholder in Public Transport bureau, management of public EV loading grid	legal obligations, political ambitions to become climate neutral in 2035
	province	management of provincial road network, shareholder in public transport bureau	legal obligations
	rijkswaterstaat	management of national motorways	legal obligations
	public transport bureau	management and procurement of public transport in the Groningen -Drenthe region	commitment to become net zero by 2030
	NS	national railway operator	already fully electrified on sustainable energy, commitment to become circular in 2030
	Arriva	regional railway operator	commitment to become net zero by 2025
	Qbuzz	regional bus operator	commitment to become net zero by 2030
	local employers Groningen Bereikbaar	employment	commitment to stimulate use of sustainable transport for commute
	local logistical companies	local logistics	commitment and need to emission free vehicles 2025 and use of local hubs
	general public	general public	Mindshift towards multi modal transport with minimal impact, ownership of zero-emission vehicles
industry	municipality	planning, licensing and enforcement, waste disposal of household waste	legal obligations, political ambitions to become climate neutral in 2035
	province	planning, licensing and enforcement of heavy industry	legal obligations, political ambitions to become climate neutral, political ambition to reduce waste to zero in 2030
	companies	emissions, use of energy and generation of heat	supply of residual heat, need to transition towards sustainable energy, economic reasons for reduction of energy consumption

	Enexis	grid operator	need for balancing supply and demand especially for large capacity users
Agriculture	province	licensing of agricultural emissions	legal obligations, political ambitions to become climate neutral
	municipality	enforcement of environmental licenses	legal obligations, political ambitions to become climate neutral in 2035
	agricultural enterprises	production of food and feed	willingness and need to reduce environmental impact
	national government	legal framework for licensing agricultural emissions	unknown yet
	shops and restaurants	sales of (sustainable and local) food	willingness and need to sell local and sustainable products
	consumers	Consumption of food	Willingness to use more local and sustainable products

4.5 Systemic Barriers and Opportunities to 2030 Climate Neutrality

Of course, there are numerous barriers towards climate neutrality. Most of them can be resolved. However, there are some barriers for which local influence does not provide a solution. Some of these are obvious. As long as cars are using fossil fuels, there will be an emissions problem. The EU and the national government, for solid economic reasoning, can't phase out petrol burners before 2030, so, it is obvious that this will remain an issue.

But some barriers deserve extra attention. For the Netherlands, electric capacity was taken for granted for a long time. But now, as we phase out gas and switch to PV and wind for our electricity, we have created a major problem: We don't have enough capacity to transport energy, while the demand for electric energy is growing.

Another barrier, that is often overseen, is the logistics of the transition. To change to a sustainable system, we'll need materials, equipment and people. The scale of this transition is huge, even just in Groningen. If the rest of the world follows, there is not nearly enough capacity to change in a decade or so.

Grid capacity and hands on the job are the two things that holds back Groningen most.

4.5.1 Diversion of the Expression of Interest

On February 28th, 2022, Groningen has expressed her intentions to take part in the Mission 2030: 100 Climate Neutral and Smart Cities, by sending in a formal Expression of Interest. Groningen was very proud to be elected one of the 112 Mission Cities, confirming its efforts and ambition to stand in the forefront of the transition towards sustainability.

In this Expression of Interest, Groningen stated the ambition to become climate neutral (as defined in the Mission) by 2030. This statement was deliberate: since 2007 Groningen has implemented policies towards energy transition, from 2014 this was changed towards climate neutrality, and from 2018 our goal was to become CO2 neutral by 2035. The Mission 2030 was an acceleration of our plans, very ambitious, but at the time it did not seem impossible.

Since expressing our interest in the Mission 2030, we have been seriously improving our plans, whilst implementing the actions we already had planned. As evidence of our unwavering ambition: the Energy program, our leading department in climate mitigation,

is the largest and fastest growing department in our organization and employs currently some 85 people.

The first order of business was commissioning of a solid re-actualisation of our CO2 emissions inventory. We also commissioned a modelling of the impact of our current policies (actions and pathways). This modelling included an analysis of the influence that the municipality of Groningen can have on the outcome of the transition.

The results were rather disheartening: though Groningen is performing well above the majority of Dutch cities and well above the legal obligations, our intended actions and pathways do not lead to climate neutrality in 2030, and even climate neutrality in 2035 is very ambitious, unlikely, but possible. Groningen certainly has a influence on the speed of the transition, but at best this would influence about 43% of the outcome.

In the same period of time, two other factors emerged, with a negative influence on the speed of the transition:

- Lack of capacity and gridlock in the electric grid at least until 2031
- Logistics: the sheer amount of labour, materials, equipment and coordination of all works can't be provisioned in the timeframe of 2024 – 2030.

These roadblocks, together with some other barriers, will be elaborated on in this chapter.

This means that the municipality of Groningen requests a deviation of the Expression of Interest. We do have the ambition to remain one of the top-performing cities in Europe, we are committing all possible assets to do so, but realistically there is no pathway to become CO2 neutral in 2035. It is our commitment to our inhabitants and stakeholders to provide realistic data and realistic policies, that is why the municipality of Groningen request permission to deviate from the EoI: Groningen aims to reduce the GHG-emissions in 2030 by 60% and in 2035 Groningen aims to become climate-neutral as intended in the EoI: minimal 80% reduction, maximal 20% compensation compared to 1990.

4.5.2 Lack of capacity in the electric grid

This factor emerged in 2023-2024 and has profound implications on our ability to act for the coming 6-8 years. It is still very much a Dutch problem: congestion and lack of capacity in our electric grid.

The Netherlands are very much dependent on natural gas as a carrier of energy. This used to be ideal for us: cheap, mostly from national resources, flexible. Natural gas is not sustainable and must be replaced. The only realistic alternative is the use of electricity. It is estimated that our electricity consumption will grow from 117 TWh (2020) to 182 TWh - 201 TWh in 2030. This electricity used to be produced with gas and coal but is now increasingly produced by solar and wind. The production of solar and wind will grow from 55 TWh (2023) to 130 TWh in 2030. This production needs to be balanced, as it is variable with weather conditions.

Our electric grid is not capable of sustaining this growth and needs to be strengthened. This needs to be done on three levels. The national grid needs to be strengthened, to cope with a growing production and growing need for flexibility because of large scale wind (in the North Sea) and solar production. The mid voltage grid also needs to be strengthened to cope with the growing demand. The low voltage grid needs to be strengthened to cope with overproduction of PV on roofs and smaller sites.

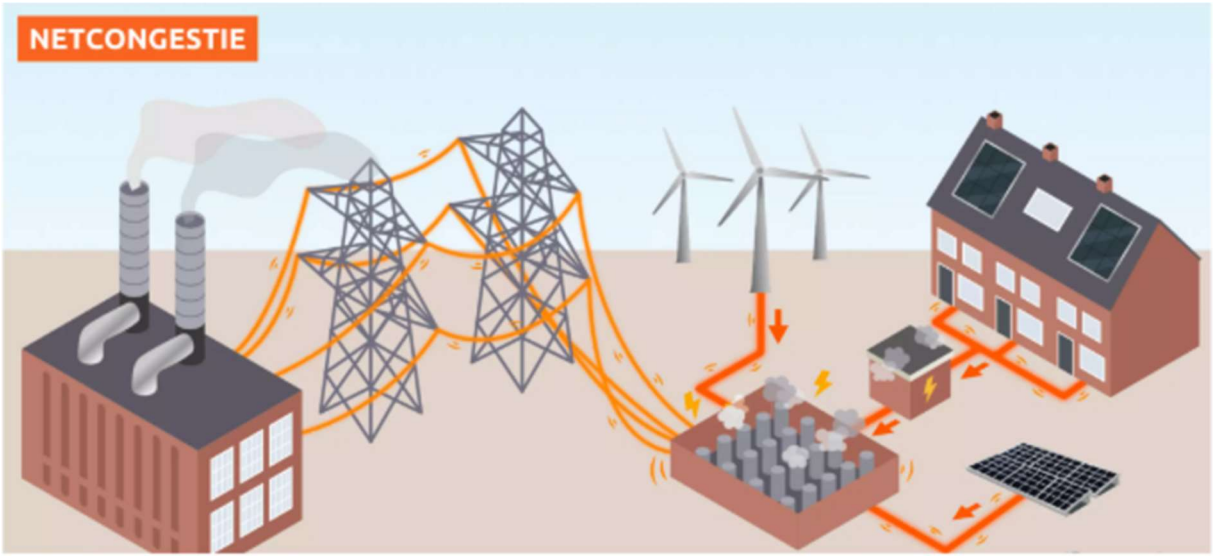


Figure 13 The Dutch electricity system (source ecudenhout.nl)

The time needed to build up the electric grid exceeds the timeframe of the Mission 2030. At this moment, the best projection for enlarging the Groningen high voltage station reckons that this will take until 2031, without delays by court cases and appeals. In Groningen we also need to add mid voltage stations and reroute several 110KV lines and we need to add some 750(!) low voltage transformers. It is likely that in the majority of streets, the grid needs to be replaced.

The consequences are dire. At this moment there is a waiting list of more than 3 years for higher capacity connections. Literally, in Groningen there are supermarkets and other businesses, that were built last year but can't open because they are not

connected to the grid. We expect that even for low-capacity connections, such as households, a waiting list will be formed somewhere in 2025. It is impossible to add fast chargers for EV, and even 'slow' public charging points may become an issue. The building of new neighbourhoods, which is much needed because of the housing issues in the Netherlands, may be delayed, and the building of new commercial sites is impossible at this moment. The congestion of our electric grid seriously impedes our ability to transform and to grow, and though Groningen is leading in tackling the local situation, mitigation of this problem is highly unlikely.

The consequences for heat transition are large. A sizable part of Groningen needs to convert from natural gas to hybrid solutions, meaning a mix from electric heat pumps and biofuels. Another 10% of the homes will go full electric. This means that in order to change our system of heating, we need a lot of electricity, which is not available for the next 6-8 years. Several regions in the Netherlands have abandoned their electric-only plans for new buildings and are allowing hybrid-solutions (gas/electricity heat pumps). Some regions even actively discourage full electric heating. Some cities even plan temporary solutions such as (natural) gas-fuelled district electricity plants. These solutions will of course increase emissions due to less optimal efficiency. As up to now, Groningen has no plans yet to alter policies regarding electric heating.

The lack of electricity also affects our plans for mobility. Groningen needs a shift from ICE to EV. The amount of electricity that these EV's needs is large. Furthermore, for convenience' sake, the chargers are demanding increasing capacity (Amperes). As long as the gridlock stays, it will hinder the conversion towards electric mobility.

Though PV on roofs is very common in Groningen (due to favourable regional subsidy-schemes), on sunny days, they typically shut down mid-day. The local supply of solar energy exceeds the demand. To protect the net-stability, the PV-converters will shut down because the net-voltage exceeds the system-limits. In a few cases, this even led to short power outages. The problem is not just that local demand and supply don't match, the oversupply also can't be absorbed by the mid voltage net. With a projected capacity

of 450 MWp PV in 2030, this seriously impedes our capacity to produce local sustainable electricity.

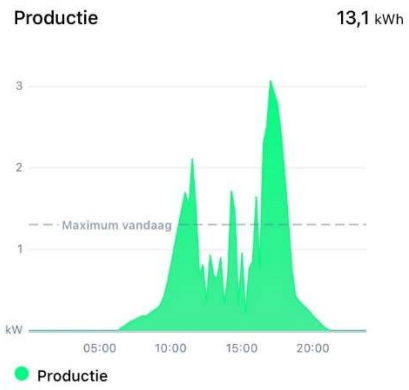


Figure 14 typical PV production on a cloudless day

Figure 14 typical PV production on a cloudless day is an example of net congestion on the low voltage grid. One can see that around 11:00 AM production drops, due to lack of grid capacity. A normal full day of PV production for this site on a cloudless day would yield 24kWh. The 14:30 peak is from using an induction stove, if a household uses energy, it can be delivered by the PV-installation.

At this moment, Groningen is ‘code orange’. This means that no new high-capacity connections are available, net extensions for new neighbourhoods or business parks are not possible, and on sunny days the feed-in of PV on roofs will shut down. It is expected to escalate to ‘code red’. That means that there is also no capacity for new low capacity connections. This would seriously hinder our housing situation and our economy. Also, stable delivery to existing connections is at risk, with local black outs as consequence.

The national grid operator TenneT has issued a warning that due to variations in supply, black-outs during certain periods of the year (winter, high demand, low PV-feed, low wind) are likely, though the severity of these black-outs are limited to a few minutes to a few hours. The likelihood of these black-outs is growing, with a peak after 2030. These black outs are not local, but will affect complete regions.

The barrier of gridlock can't be easily remedied. Yes, the grid(s) can be strengthened, engineered to new demand and supply. This is not just a question of money. There is a very solid business case for electric grids, the costs of investments are subsidized and socialized. The operators, TenneT and Enexis are regulated businesses, with national and local governments as shareholder. Though the business case may be solid, the upfront investment is large and will have to be funded with private capital, requiring guarantees.

Planning and execution of grid-improvements will take a lot of time. Resources (materials, equipment and certified personnel) are scarce. In the annual report 2033, TenneT sums up all projects that are being done to mitigate congestion. Almost every project shows notes like: 'delayed due to lack of workforce'. Sometimes another reason for delay is mentioned: delivery time of key components takes years. The lack of workforce means that maintenance of the grid is in danger, and this means more people are scheduled to do repairs, thus taking away people from the investment in capacity.

The impact on public space is enormous. Our regional grid operator Enexis expects to dig a million kilometres of trenches in the coming 10-15 years. Planning of high-voltage lines takes many years. For Groningen, it is expected that some 755 new low voltage transformers (small buildings the size of a shed) need to be placed in the municipality. And to and from these buildings, into almost every street, new cables must be dug. For the medium voltage stations, an extra 13Ha of space is needed. In a densely populated area like Groningen, this has a high impact.

Currently, the estimations for resolving the gridlock are between 5 and 11 years. **This means that reaching climate neutrality by 2030 is extremely unlikely and reaching climate neutrality by 2035 might become challenging.**

Table 10 Barrier Gridlock

barrier	***stakeholders***	***severity***	***Mitigating actions***
Gridlock in electric grid due to increasing demand and fluctuations in supply, lack of electric capacity in the next 6 years	- grid operators TenneT and Enexis (management and building grids) - national government (permits, planning finance, regulations) - provincial government (planning permits) - municipality (local planning, permits, promoting smart grid actions)	Very severe, likely to obstruct speedy energy-transition	- Faster regulations and permitting (emergency laws) by national and provincial government - Smart grid solutions on district scale - Capital-injections into the grid-operators - Smart design of new grid to minimalize spatial impact

			- Lobbying for preferential position for Groningen Mitigating actions will have some impact, but will not remedy the barrier

4.5.3 Logistical barriers: materials, equipment and personnel

In the Groningen region we are facing large scale reconstructions and repairs of homes due to earthquakes induced by gas mining. Whole villages need to be rebuilt; their inhabitants need to be relocated for the time being. Of the 220.000 home addresses in the region, 27.611 addresses need reinforcement or reconstruction (source: Nationaal Coordinator Groningen, May 31st, 2024). This is just for reconstruction; repairs are not included.

In total 230.287 reports of damage have been registered, of which 212.976 have been processed. The total amount of awarded damages was € 1.353.350.689 (physical damages to building). This also translates to loss of value of real estate: € 511.265.815 has been awarded as damage as a result of loss of value. Every inhabitant of the core-region of the earthquakes is eligible for €5000 in immaterial damages.

There is an online dashboard with data on the damages: https://schadedoormijnbouw.nl/dashboard.

In the municipality of Groningen, damaged property is most widespread in the villages in the North-East of the municipality, where new temporary neighbourhoods with 'replacement-homes' have been built. In the municipality of Groningen, 5.138 addresses need reconstruction.

Figure 15 Temporary homes in the village of Ten Post

We have experienced that the logistics of operations of these scales are difficult. You can't rebuild home for home, you'll need to plan for whole neighbourhoods or villages at the same time, otherwise, the villages will remain inaccessible for years. If you do so, you'll also need to procure these works at large scale, complicating matters and raising the risks. The original estimates for the reconstruction operation had to be revised again and again, now it is estimated that this operation will not be ready by 2030.

With this experience in mind, let's look at the logistics of decarbonization, which will add on the existing workload of the construction sector. The amount of work that we need to do for the transition to net zero is immense. A quick calculation of the isolation program shows that for isolation alone we'll need some 16.500 labour years. This is without retrofitting the technical installation of the homes. It is estimated that our grid operator needs to dig 1 million km of trenches in its region to strengthen the network. We need to build a heat grid connecting 40.000 homes and a 40km pipeline to the Groningen seaport. And we need to upgrade our sewage system and redesign public space at the same time, in order to adapt to the climate change. These works should be done in a city that needs to be functioning as usual.

The puzzle of keeping our city and our villages accessible is getting extremely complex. Reconstruction of unsafe homes and strengthening the electric grid take priority, but we can't wait long with isolation and transforming our heating system.

Combination of interventions in the public space are considerable cheaper than consecutive interventions. Groningen calculated that in some streets, it will save some 33% on the total costs of intervention. Ideally, we should combine all interventions in the public space in one timeframe, but realistically, the different stakeholders have different timeframes and different financial possibilities. Together with the scale of the interventions and the voluntary nature of cooperation, planning becomes extremely complex.

To add to the complexity: unemployment in the Netherlands is low; there are more job openings than unemployed people. Already, we depend heavily on migrant labour, especially for manual and technical labour. Though our vocational schools do everything they can do to mitigate shortages in labour supply, we lack people. For the isolation program, it has been estimated that local companies can supply just 15% of the workload. Already, because of the reconstruction works, the construction sector in the region is stressed, and growing as rapidly as possible within the limits of availability of personnel.

The amount of materials and equipment we need is enormous: electric cables, ducts, isolation materials, heat pumps, induction stoves, solar panels, windmills, construction materials, trees and plants, tarmac and other road materials.

The production of many of these materials is planned for the status quo, but not for an exploding demand. Groningen is not the only city that needs to transition, in due time all European cities will need to do so. It is clear that in the future, not only will the costs of materials rise, but also the availability will fall short. This is especially the case for

scarcity bio-based building materials, which should be used to minimize CO2-impact. The Netherlands hardly produce bio-based materials such as wood or hemp. Nearly all materials need to be imported with high costs and low demand as a result.

In the city of Groningen, the strengthening of the electric grid, the construction of a heat grid, rebuilding of sewage for climate adaptiveness, redesigning streets to our new standards for mobility and retrofitting buildings mean that to reach climate neutrality, every single street will face digging up and rebuilding, every house will be touched, almost literally no stone will remain untouched.

Mitigation of this problem of lack of labour, scarce materials and complex logistics can't be easily mitigated. If we would have the people to do the jobs, it would take years to educate them. Labour migration could be a solution, and is already quite high. The absorption of migrants in society is highly debated, especially after the 2023 national elections, which showed a growth for the anti-migrant populists (though not in Groningen). And labour migration has adverse effects in the countries of origin, such as Poland, Bulgaria and Romania: a drain of talent.

Better coordination will help somewhat, but it will not mitigate lack of people and materials. On a larger scale, automation and new business models could help, but it will take years to develop. The only real solution is spreading out the workload, which means that climate neutrality by 2030 is not realistic, and climate neutrality by 2035 is highly ambitious.

Table 11 Barrier Logistics

.	***stakeholders***	***severity***	***Mitigating actions***
Logistical problems: shortages in materials, equipment and labour	- the European Union (coordination, developing new markets and production-lines, stimulation of bio-based building, migration, regulations) - national government (stimulating new markets, education,	Severe. Already shortages in people, equipment and materials, rising prices This barrier has negative influence on barrier Lack of Electric capacity	- Better coordination of (public and private) works and of production of materials and equipment - Development of new business models and innovation of existing processes - Automation

	migration, regulations) -municipality (coordination, procurement policies, housing of migrants, education) -business (hiring people, innovation in building techniques, coordination, new business models) - Schools for vocational education: provision of skilled workers		- Promotion and education for skilled work - Promotion of migratory work Mitigating actions will have impact, but will not remedy the barrier

4.5.4 Financial barriers

The transition towards climate neutrality is expensive. Groningen expects to invest 4.25 billion euros towards 2030. Experts indicate that some 80% of this investment will need private funding.

Private investment will be done on economic reasoning: business cases, trade-offs between risk and reward, scale as factor. However, climate mitigation is a societal need and not necessarily a profitable business-proposition. This means that we need to accept that either we need to make business cases viable with subsidies or charge societal costs.

The first problem with this is the limited useable budget that is available to local governments. Our budgets are limited, and a Dutch municipality has very limited fiscal instruments. Reformation of national funding for Dutch municipalities is under discussion. National policies of decentralization have increased the workload of municipalities, but in the same period, budget cuts were enforced. A large part of the budget is earmarked (the Groningen yearly budget is around €1.3 billion, of which we can decide ourselves some €15 million). The national trend is towards earmarked project funding (Specifieke Uitkeringen or SPUK's), which means more overhead in

planning and reporting, and less freedom in spending. It also means that municipalities need a lot of expertise to secure their share of these budgets.

So, available (co)finance from municipalities is limited, and are often project based, so not freely spendable.

Secondly, the scale of municipal projects is too large for small investors or the municipality itself, but not large enough for major investors, such as banks, pension-funds and capital-funds. From NZC and the EIB, financial expertise is offered to pool municipal projects, but these are new instruments and they have not yet proofed their value. Municipals themselves often lack the market-based financial expertise needed for setting up pooled resources or sound financial propositions.

Table 12 Barrier Financial

barrier	***stakeholders***	***severity***	***Mitigating actions***
Access to financial means	-municipalities (needing private investment and public budget) - national government (fiscal instruments, division of public budgets, financial guarantees, subsidies) - EU (CO2 costing, subsidies, access to financial engineering, guarantees) -private investors (provision of private funding, understanding needs of municipalities)	Moderate severe. The Netherlands have better funding than many other countries, funding for trials and small projects available, but upscaling is problematic.	- Access to financial knowledge and new financial instruments, such as guarantee-funding - Changes in fiscal regulations - Decompartmentalization of public funding for municipalities - changes in charging for societal costing (i.e., higher costs for CO2 emissions) or direct taxation of CO2 emissions - Influencing national regulations on

			finance for municipalities

4.5.5 Regulatory barriers

Since a municipality has to uphold and obey the law, it is limited by regulatory barriers. A detailed overview of regulatory barriers has been produced as deliverable of the Horizon funded project 'Making City'.

In the domain of **Energy systems**, we are limited by national energy laws (derived from European directives), regulating the energy market and by data protection laws. Groningen has a critical view on the liberalized energy market. The municipality has formed its own energy company (after selling it in the '80s), it has formed its own heat grid company and it stimulates cooperative initiatives of inhabitants. The regulations sometimes are prohibitive if we want to stimulate local energy exchange, but also in the roles of our heat grid company (only distribution, no storage or production).

Data-protection laws prohibit the gathering of detailed (to the level of the individual user) data of energy usage via smart-metering. This means that monitoring and data-driven decision-making is hampered. Also, in case of working with businesses, the data is competition-sensitive, and thus not publicly available.

In the domain of **Built Environment**, construction-codes and planning procedures can be prohibitive. Especially for bio-based building, codes are not keeping up with the technology. Planning procedures in the Netherlands can be extremely complex and time-consuming, a new law on planning has been introduced in 2024 but has not been tested out completely. Mistakes in the process, for instance in the required public participation can lead to extremely time consuming and costly legal action.

In the domain of **Mobility,** the municipality is limited by national regulations (f.i. there is debate about the admissibility of zero emission zones), traffic laws, European regulatory frameworks on manufacturing and sales of cars.

In the domain of **Industry**, a Dutch municipality cannot be stricter on emissions than national law. However, for new industry a municipality can regulate with planning zoning.

For **Agriculture**, a Dutch municipality has very limited regulatory instruments. We are depending on national law (partly enforced by the provinces) which in turn is heavily influenced by European rules. Limitations in the extensive agriculture in the Netherlands are subject to heated political debate, there is conflict between European regulations and national policies (or the lack thereof). There are no local mitigating strategies.

Table 13 Barrier regulatory

barrier	***stakeholders***	***severity***	***Mitigating actions***
Regulatory barriers	Municipality, province, national government, EU, companies	Moderate We have not identified regulatory barriers that would pose extreme threat to the mission goals; however, we do face some barriers	Cooperation with the Dutch Mission cities and the national government in the National Support Structure, to identify regulatory barriers and to see if these barriers can be mitigated.

4.5.6 Difference in goals between EU and Netherlands and Groningen

Earlier we highlighted that the 2050 (almost) climate neutrality goal of the 2019 European Green Deal, the 2018 Dutch National Climate Agreement and 2021 Dutch Coalition Agreement also form barriers for the Dutch Mission Cities, which have a 2030 target.

Based on these European and national commitment, European and national policies and regulations have been set up, and financing programmes have been developed, which are focussed on the 2050 and not the 2030 target. Moreover, Dutch municipalities have a specific funding structure. They depend for more than half of their budget on national funding, they compete for national funding supporting climate neutral projects and the Law financing of decent financing of decentralised governments puts standards for the risk in raising finance (borrowing) and in deploying funds (investing).

Both the European and national policies and regulations and the funding structure constrains the freedom of municipalities to accelerate to a 2030 climate neutrality goal of the Mission Cities and could lead to a potential missed opportunity as together, the seven Dutch mission cities represent about eighteen percent of the Dutch population and roughly twenty percent of national CO2 emissions. The progress these seven cities make will have a direct impact on European and national CO2 emissions reduction. Another connected barrier is the lack of a more locally focused emissions monitoring system to support the Mission Cities in mapping their emission progress.

At the same time, having seven Dutch Mission Cities in the Netherlands has created a unique opportunity for a closer cooperation between these mission cities and three Ministries (ministries of Climate and Green Growth, Housing and Spatial Planning and Infrastructure and Water Management) on specific climate issues via the National Support Structure (NSS). The NSS is a platform for the Dutch cities to meet and discuss their needs both with the National Government and relevant agencies, and amongst each other.

The NSS is also facilitating a series of 'deep dive' trajectories to address priority barriers highlighted by the cities in order to facilitate breakthroughs in collaborative climate action. Through the collaborative multi-level governance conversations in the NSS, the national government and the Mission Cities are also exploring what further support may be needed – in the period ahead this could include refinement of climate emissions data infrastructure and indicators; policy & regulatory innovation; and finance innovation. Additionally, the NSS will continue to engage positively and to support the cities in their ambitions. Concretely, the NSS will take the initiative in analysing all Dutch CCC's, in order to create an aggregate picture of the challenges that all Dutch (Mission) cities are facing in their transition.

The Dutch Mission Cities have identified four conditions to translate the previous described barriers to opportunities for making the desired sustainability progress. These four conditions are first introduced and then we list the specific policy areas in which we see both barriers and opportunities from and for national and European involvement to succeed.

The four conditions are:

1. Learning among and beyond the current NSS partners:

    a. Learning among the NSS partners: via deep dive dives, part of the CapaCITIES program, the NSS partners have formulated similar barriers and

shared lessons learned. The Dutch Mission Cities are also all participating in a NZC Pilot City call on the District Investment Platform.

As these cities are increasingly implementing actions, they face the barrier of being a frontrunner as the current national policy context is not allowing them to take the actions they would like to take. There is a need for more policy freedom to experiment with the measures needed at the local level to achieve the sustainability transition. For example, the local freedom to introduce a zero-emission zone, road pricing or to impose statutory requirements on the built environment. The purpose of the mission is to explore where we can accelerate, for which the Mission Cities need experimentation.

b. Learning beyond the NSS partners The Ministries see the Mission Cities as frontrunners, and other Dutch municipalities can learn from the process and the actions the Mission Cities are taking. Efforts are taken to capture these lessons learned and copying or upscaling these to other Dutch municipalities

2. Increase governance Innovation and collaboration at all levels:

Although the timeline might differ, we all share the same climate neutrality goal. More cooperation between decentralized authorities, the national government, and the EU in order to be able to work together where freedom of policy is not possible. Moreover, multi-level governance collaboration can effectively embed the lessons learned at the local level in national and European policy and achieve sufficient market demand through sustainable purchasing.

3. Further examine alternative ways of public and private financing:

Financial cooperation to realise the physical preconditions required for the climate transition. The investment plans of other Mission Cities have shown the importance of attracting private sector financing to reach the climate neutrality goal. The Dutch Mission Cities are already looking into the financial space to realise heating networks or cooperation to mobilise private capital for the sustainability transition. Moreover, the Dutch cities have strong ties with their local stakeholders; however, to move forward, more than participation and co-creation, they need co-investments.

4. Develop a Dutch standard for local emissions monitoring

The CCC process has unearthed the lack of a sufficient data to monitor the local emissions impact assessments and qualifications. With their CCC's each Mission City is pioneering on monitoring. Although a barrier now, the lessons learned from each Mission City can support a more resilient standard of monitoring when the Dutch Cities iterate their CCC's and when other Dutch municipalities take up the challenge to become climate neutral.

5 Part B – Pathways towards Climate Neutrality by 2030

The modelling of an energy system and the consequent future reduction of CO2 emissions is extremely complex. An energy model depends on hundreds of variables; these variables may be interdependent.

5.1 The Energy Transition Model

Groningen uses the Energy Transition Model, a free, open sourced, independent scenario builder (see www.energytransitionmodel.com). The scenario is built on the initial numbers of 1990 and 2019 runs to 2035. As far as possible, the actions and most likely pathways have been used as input. The goal of net zero emissions in 2035 is set, the influence on the energy system is backcasted from that.

The most obvious conclusion is that the results will almost with certainty diverge from the reality in 2035! Obviously, we cannot predict future developments and events. The influence of wildcards can be large: the COVID-19 pandemic and the Russian invasion of Ukraine influenced our energy system more than anyone could have predicted. The model does not give an indication of the uncertainty.

In Appendix D is a report generated by the model of the scenario for this plan.

We see that Groningen will use 35% less energy in 2035. The CO2 emissions are almost zero, logically, because this was set in this scenario. Renewable energy will grow from 5,7% (1990) to 71,5% (2035).

Carbon capture on any sizable scale is no option in Groningen. There are some CCS project underway in the Netherlands, but they are restricted to industry outside our region. Though plans for carbon capture and storage in the Groningen underground (old gas fields!) have been proposed, the Groningen population is not very enthusiastic, to say it mildly, given the experiences they had with gas mining.
With CCS out of the picture, the only way to reach this net zero target is massive use of biofuels, especially green gas. This requires large technical investments, and a change of land use in the Netherlands. The administrative area of Groningen Municipality will not be able to produce this amount of green gas.

It is also apparent that it will become hard to run an economically viable power plant in this scenario. The use of renewable energy may depend on weather, time of day and period of the year. The demand and supply will be hard to balance. You'll still need power plants to supplement this balance in order to ensure a stable system. Nuclear power might be an option, but the timeframe of building a nuclear power plant is beyond the scope of the mission (in the Netherlands there is 1 nuclear power plant, providing 3% of the demand and is supposed to shut down in 2034). This means that we still need

conventional power plants running on (expensive) biofuels, but not running on a constant and optimized load.

If we were to use natural gas (100%) instead of green gas, our relative emissions reduction would still be an impressive 91,3%, even if we were also to use fossil fuels for transportation emissions would be reduced with 87,2%. However, without mechanisms for carbon capture, net zero would be out of reach. In our models and carbon accounting we do not use biogenic capture, as it is in the long run almost net zero to slightly net positive emissions.

5.2 Berenschot model

Groningen also has used another approach of modelling: regression of our current policies towards the future, based on the inventory, our actions and pathways and our influence. This was done by Berenschot.

It is obvious that a local government has limited influence on the outcome of transition towards climate-neutrality. Other factors play important roles, such as national and European regulatory frameworks, public opinion and political climate, economic health etc.

Groningen asked Berenschot, who provided our CO2 inventory, to forecast the effects of our policies and plans on climate neutrality. Our plans were scored along an axis of influence, from no influence to high influence.

The results were sobering. According to this model, we will not reach climate neutrality in 2035: the exogenous influence is quite large, and it is likely that this will cause us not to reach net zero.

Table 14 Berenschot model predictions

Jaar/ sector	***Industry***	***Electricity***	***Mobility***	***Built Environment***	***Agriculture and land use***	***Total***
1990 (in kton)	700	475	295	400	130	**2.000**
2020 (in kton)	295	350	295	255	115	**1.310**
2030 (in kton)	215	75	245	225	100	**875**
2035 (in kton)	165	-70	245	126	100	**565**
2020 (%)	58%	27%	0%	36%	10%	**34%**
2030 (%)	69%	84%	16%	43%	22%	**57%**

2035 (%)	77%	115%	17%	68%	23%	**72%**

Berenschot estimated local influence on the outcome to be 43%.

The levels of influence were defined as follows:

Table 15 Levels of influence

Level of influence	***Description***
large	The municipality has a lot of influence, f.i. as permitting authority or as authorized supervisor. The municipality has some dependency on the willingness of other levels of government or other parties
medium	The municipality has a certain level of influence on emissions, but is also quite dependent on the cooperation of others
limited	The municipality is limited in its influence and is to a large extend dependent on others. The municipality has no authority and limited control
very limited	The municipality has very limited influence, the main influence is on national level. This is the case with 'cluster 5' companies and (sub)sectors that are highly international of character
none	The municipality has no influence on the emissions of the (subs)sector

The possible roles of the municipality are listed as:

Table 16 Roles of the municipality

Role	***description***
Authorized supervision (bevoegd gezag)	The municipality has legal executive authority; it can enforce the following of rule and order

Ownership	The municipality is owner of assets and thus has authority and obligation
Participation and shareholdership	The municipality participates and/or is shareholder in organizations, durable installations or infrastructure and could actively develop and stimulate sustainability in the organisation
Subsidizing and financing	The municipality can influence organizations or inhabitants through subsidies or financial support
Stimulation: initialize, facilitate, boost	Stimulation towards sustainability of stakeholders who otherwise were less likely to do so. Connecting different stakeholders and organisation of cooperation
Communication and awareness	Communication towards stakeholders on sustainability stimulation of awareness on these subjects
Knowledge, data and monitoring	Sharing knowledge on subjects that are in the municipal domains, commissioning of research, structuring and sharing of high-value data
Lobby	Use of relations and networks to set the agenda on other levels of government

Notable is that Groningen has a larger than average influence on emissions. This is because Groningen does not have a lot of (heavy) industry, the influence of agriculture is limited and our mobility is more than average within the city, as opposed to through-traffic. The main source of emissions is our built environment, which is, to a certain degree, influenceable.

In the following figure, the different levels of influence are depicted for 1990, 2020 and 2030 (in Dutch, green is high influence, dark red is no influence).

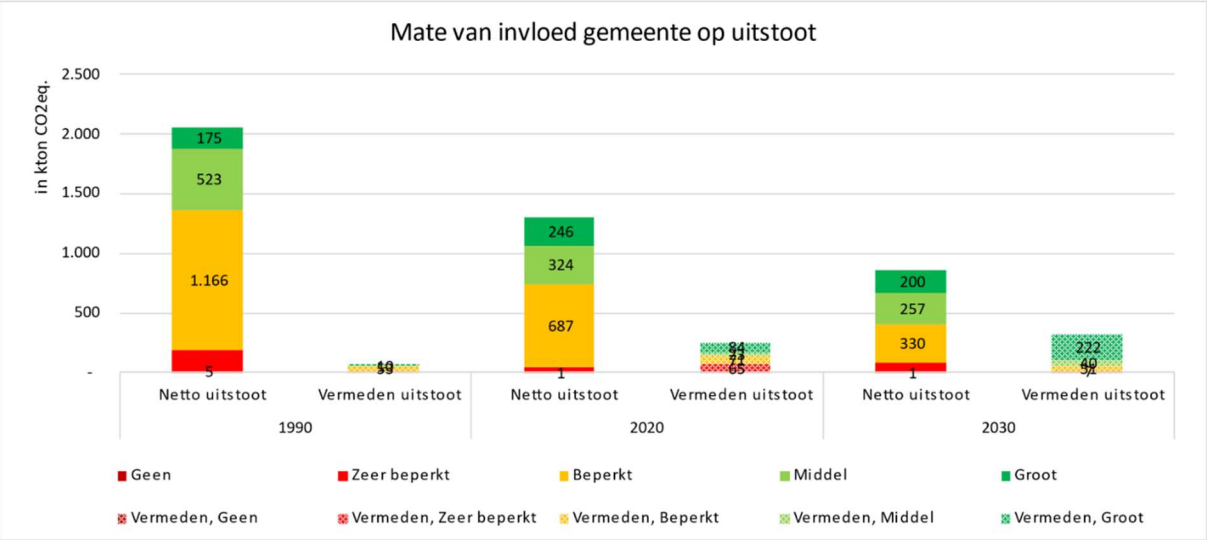


Figure 16 Influence on emissions

If you look at the emissions that might be reduced within the influence of the municipality, compared with the total emissions, it is clear that the municipality of Groningen is on track.

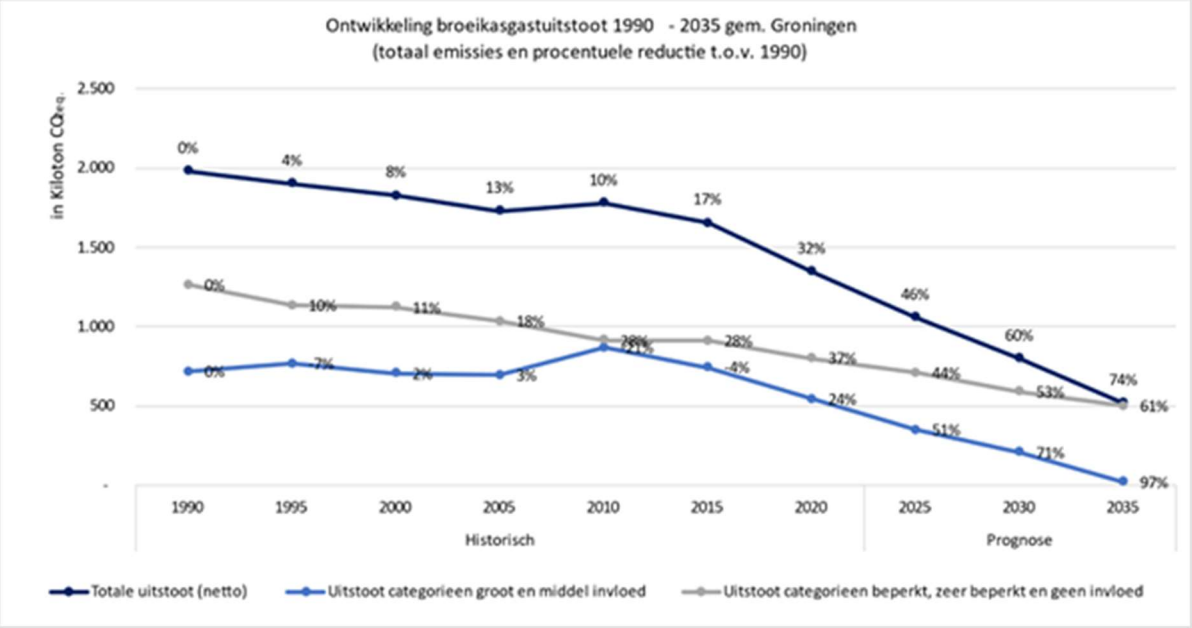


Figure 17 reductions of emissions total vs. Influenceable

With the current proposed actions and pathways, Groningen is expecting to reach 97% reduction of emissions for which the municipality has large or medium influence on. For those emissions that are out the scope of influence, Groningen expects to reach a reduction of 61%. This totals to an overall reduction of 74%.

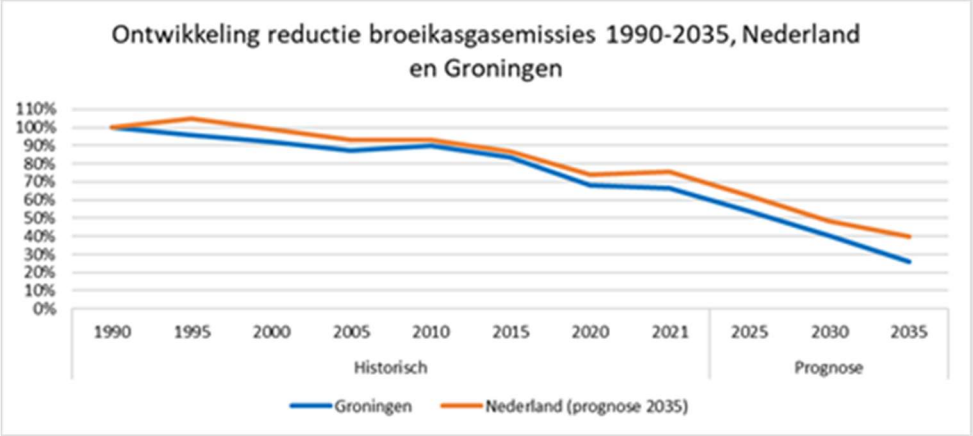


Figure 18 reduction of GHG emissions the Netherlands vs Groningen

Both historically, and in the projection for the next 11 years, Groningen the Netherlands as a whole in terms of reductions of GHG emissions. This gap in performance is likely to grow, according to Berenschot.

5.3 Emissions gap

The back casting Energy Transition Model shows that to become fully climate neutral, Groningen needs to rely heavily on the availability of biofuels, and that the economic sustainability of our power plants is at danger.

The forecasting model of Berenschot predicts that we will not fully reach climate neutrality by 2035, even if we would do everything possible.

Of course, it is unlikely that reality will look like either of these models. With that in mind, though the municipality of Groningen aims to be climate Neutral by 2035, we are well aware that to get there, we can't do it without a societal change in the world around us. Whether this change will happen and if so, in what tempo this will happen, is out of the scope of influence of Groningen.

It is likely that there will remain GHG emissions, the ‘gap’ between the results of our actions and those emissions we can't influence. Innovations and new technology may help. One of those emerging technologies is the use of hydrogen as carrier of energy.

Other possible avenues of relieve may lay in small scale nuclear fission reactors, with potential issues for generations to come. One could even dream of nuclear fusion as source of clean energy.

Barring these technological wildcards, if there remain emissions in 2035, the next best thing to do is speed up the transition, thus lowering the total of GHG emissions over time. A ton of CO2 saved in 2030 equals 5 tons of CO2 saved in 2035. The curvature of the path to climate neutrality may be of more importance than the endpoint.

Rather than perfection, the municipality of Groningen aims for immediate action, even though Groningen is limited by a number of roadblocks. As explained in the Groningen commitment, our commitment is based on realism and the communication of realistic expectations to our stakeholders.

5.4 Climate Neutrality actions and pathways

The core of the Groningen climate plans are of course the actions we take, and the actions we should take in the future.

Actions are defined as: measures to make impact on GHG emissions or other desired outcome that have been planned and are in execution or are about to be executed.

Pathways is the term Groningen uses for future actions, that are foreseen, but are not planned to any detail and are not yet ready for execution.

So typically, an action could be: we are going to insulate 5.000 homes in Selwerd by 2025 to energy standard, and a pathway could be: we need to insulate 80.000 homes by 2035.

The lists of actions and pathways are in no way complete. Stakeholders may do actions of which we don't know. And there is a level of aggregation. As an example: Groningen intends to promote EV-mobility. This implies that the municipal organisation should also convert to EV's. For this, actions are being carried out. However, this 'sub'-action will not be listed.

The action may have impact on GHG emissions. Some actions don't have direct impact but may be necessary as a catalyst for other actions. Strengthening the electric grid, for instance, does not directly impact CO2 emissions (in the operational phase). But without enough electric power, we can't get rid of natural gas.

Some actions have impact on other desired outcomes. Combatting poverty has little impact on CO2 emissions, but the societal impact is as important.

For some actions it is very hard to model the impact on GHG emissions. Especially for the many actions we do in the mobility sector. The actions are on micro-level, but our emissions are calculated on macro-level. The translation from micro to macro is difficult, if not impossible. However, this does not mean that the actions are without effect.

The sum of all reductions on GHG emissions from the actions and the pathways will not be enough to reach climate neutrality. A lot depends on influences outside the local scope, as discussed in the previous sections. Whether to define this difference as an emission-gap, or as difference to be resolved with extraneous processes is a matter of debate.

5.4.1 Actions

Table 17 list of actions

Number	***category***	***name***	***CO2 reduction (Kton CO2 eqv per year)***	***CO2 avoided (KTon CO2 per year)***
1	built environment	wijkgerichte aanpak: isolatie noordwestelijke wijken	20928	
2	built environment	aanpak energiearmoede	0	0
3	built environment	aanpak VVE's	0	0
4	built environment	energie coaches algemeen	0	0
5	built environment	Energie Transition fund	0	0
6	energy system	wamtestad distributienet	13273	

7	energy systems	solarboilers on roofs		2
8	energy systems	solar heat plant Dorkwerd		4680
9	energy systems	restwarmte datacenters Zernike		18000
10	energy systems	zonneparken		25600
11	energy systems	PV on roofs		54400
12	energy systems	Groningen stroomt door	0	0
13	energy systems	Gemeentelijk Energie Bedrijf	0	0
14	industry	groningen afvalvrij 2030	10649	12622
15	industry	Groningen werkt slim	15077	
16	mobility	Emission free zone	1000	
17	mobility	Emission Free Public Transport	37680	
18	mobility	EV strategy	0	
19	mobility	mobility plan Groningen goed op weg	5168	
		Total	**103775**	**115304**

The actions are described in the following lists. The financial implications are part of the Climate Investment Plan, and not described in this document.

Table 18 Detailed description of the actions

		Individual action outlines
	Action number	1
Action outline	Action name	wijkgerichte aanpak: isolatie noordwestelijke wijken
	Action description	The neighbourhoods in the North-Western part of Groningen are less affluent than others. The quality of housing is lower, poverty is an issue for many of the inhabitants. In this action, the municipality will combine actions to improve the neighbourhood (redesign of public space) and investments in the social structure of these districts with retrofitting and insulating homes and connecting homes to a heat grid.
	Field of action	built environment
Implementation	Responsible bodies/person for implementation	Municipality
	Primary target	isolating 22000 homes to isolation standard, connecting these homes to heat grid
	Secondary targets	renovation of see-saw neighbourhoods, climate adaptation of neighbourhoods, new standard of public space, mobility shift towards less car use, inclusiveness of marginalized groups, better access to social services, mitigation of (energy)poverty
	Involved stakeholders	Warmtestad, social housing corporations, Wij Groningen (Social services), private homeowners and renters, HOA's, contractors

	Comments on implementation – consider mentioning resources, timelines, milestones	Already started (2020), completion by 2030. First districts are Selwerd and Paddepoel, in 2024 also started in Vinkhuizen. This project is participating in the Dutch Pilot Cities project The approach includes door-to-door actions, where teams of energy-coaches and social workers try to reach every inhabitant. The action will be carried out in 5 phases, the 3 first phases have started and partly been completed, the next phases are in planning. The project is financed by many sources, the idea is that inhabitants with less than 140% of minimum income will be enabled to isolate and connect to the grid without financial risk.
Impact	GHG emissions reduction estimate (total) per emission source sector	20928 Kton CO2 eqv in sector built environment
	Avoided GHG emissions by generation of renewable energy	-

Individual action outlines

	Action number	2
Action outline	Action name	aanpak energiearmoede
	Action description	targeted approach of household in energy poverty, isolation, energy efficient appliances, if possible connection to heat grid
	Field of action	Built environment

Implementation	Responsible bodies/person for implementation	municipality
	Primary target	Mitigation of poverty
	Secondary targets	inclusiveness of marginalized groups, better access to social services, increase health and life expectancy, better chances of education and employment
	Involved stakeholders	Wij Groningen (Social Services), inhabitants
	Comments on implementation – consider mentioning resources, timelines, milestones	Targeted approach of households throughout the municipality with an income of less than 140% of the minimum income. These inhabitants may apply for a stadjerspas which gives access to many facilities, including sport, culture, free public transport etc. In terms of energy, the inhabitants get offered the services of an energy coach, who helps with isolation and retrofitting, access to subsidies (up to 100% of the costs of retrofitting), small energy measures (LED lights etc) and a trade-in of old, energy-intensive household appliances for new, energy efficient ones. Target is no energy-poverty in 2030.
Impact	GHG emissions reduction estimate (total) per emission source sector	Not directly calculated
	Avoided GHG emissions by generation of renewable energy.	Not directly calculated

	Action number	3

Action outline	Action name	aanpak VVE's
	Action description	Targeted approach of homeowner associations.
	Field of action	Built environment
Implementation	Responsible bodies/person for implementation	Municipality
	Primary target	Enabling retrofitting building owned/managed by HOA's
	Secondary targets	Inclusiveness of marginalized groups, combatting poverty
	Involved stakeholders	Municipality, HOA's, banks
	Comments on implementation – consider mentioning resources, timelines, milestones	Some 40% of all homeowners are living in a multi-tenant building, where the upkeep of the building is managed by a Homeowner Association. For these HOA's retrofitting is often difficult. Decisions on retrofitting the building need to be taken by a qualified majority of the owners, and not every owner is capable or interested in retrofitting. If the owners want to retrofit, they may face financial hurdles, because these retrofits not directly connected to the ownership and the hypothecary loans. In this action, HOA's are being advised on retrofitting (technical, financial and organisational), guided towards subsidies and finance. Target is retrofitting all HOA managed buildings by 2030
Impact	GHG emissions reduction estimate (total) per emission source sector	Not directly calculated
	Avoided GHG emissions by generation of renewable energy.	Not directly calculated

Individual action outlines

	Action number	4
Action outline	Action name	Energie coaches
	Action description	General availability for inhabitants Groningen of energy coaches for questions on isolation, retrofitting, transition towards sustainable heating, PV on roofs
	Field of action	Built environment
Implementation	Responsible bodies/person for implementation	municipality
	Primary target	isolation to isolation standard, transition to sustainable heating, PV on roofs
	Secondary targets	Influencing public opinion towards more sustainability
	Involved stakeholders	Municipality, inhabitants
	Comments on implementation – consider mentioning resources, timelines, milestones	A team of energy coaches is available for all inhabitants, both passively (on demand) and actively: public actions, presence on public events etc. Actions include free distribution of small energy measures (LED lighting, isolation tape, radiator foil etc.) The team is already in action.
Impact	GHG emissions reduction estimate (total) per emission source sector	Not calculated
	Avoided GHG emissions by generation of renewable energy.	Not calculated

Individual action outlines

	Action number	5
Action outline	Action name	Energie Transitie Fonds
	Action description	municipal fund to help households in poverty with financial means for transition towards sustainable energy. This fund is, filled by national subsidies, and suppleted by (future) profits from municipal energy company
	Field of action	Built Environment
Implementation	Responsible bodies/person for implementation	Municipality
	Primary target	Combatting energy poverty
	Secondary targets	Enabling retrofitting of homes
	Involved stakeholders	Municipality, municipal energy company (GEB), in habitants
	Comments on implementation – consider mentioning resources, timelines, milestones	A revolving fund to help households with an income of less than 140% of the minimum income. The initial capital was municipal budget, suppleted with subsidies from the national government. The fund will be filled with the profits of the newly formed Municipal Energy Company (GEB) that will exploit local large scale renewable energy production (PV, wind). The fund is already in action
Impact	GHG emissions reduction estimate (total) per emission source sector	Not calculated
	Avoided GHG emissions by generation of renewable energy.	Not calculated

Individual action outlines

	Action number	6
Action outline	Action name	Heat Grid
	Action description	build of heat grid, capable of providing some 22000 home eqv of heat
	Field of action	Energy systems
Implementation	Responsible bodies/person for implementation	Warmtestad BV
	Primary target	Connecting 22.000 homes to a heat grid with sustainable heat sources: 22763 Weq in 2030= 682890GJ,
	Secondary targets	Transition from natural gas for heating to sustainable sources of heat
	Involved stakeholders	Warmtestad BV, municipality, Waterbedrijf Groningen, social housing Corporations, heat source companies/ residual heat suppliers, homeowners
	Comments on implementation – consider mentioning resources, timelines, milestones	The municipality together with the Groningen water company established Warmtestad BV, a company that will distribute heat through a heat grid. This company (50/50 shareholdership ownership by the founders) is in the process of building and enlarging a heat grid, connecting it to sustainable resources (residual heat from datacenters, a solar heat plant) and provides heat to some 6000 homes (equivalent) already
Impact	GHG emissions reduction estimate (total) per emission source sector	13273 KTon CO2 eqv in energy systems

	Avoided GHG emissions by generation of renewable energy.	-

Individual action outlines

	Action number	7
Action outline	Action name	Solar boilers on roofs
	Action description	Stimulation of installation of solar boilers on roofs for warm water provision
	Field of action	Energy systems
Implementation	Responsible bodies/person for implementation	Homeowners
	Primary target	Installation of 10MWp heat
	Secondary targets	Transition from natural gas towards sustainable sources of energy
	Involved stakeholders	Homeowners, municipality, installation companies
	Comments on implementation – consider mentioning resources, timelines, milestones	Promotion and information on installing solar boilers on roofs, helping with access to national subsidy
Impact	GHG emissions reduction estimate (total) per emission source sector	2 KTon CO2 eqv in Energy Systems
	Avoided GHG emissions by generation of renewable energy.	-

Individual action outlines		
Action outline	Action number	8
	Action name	Solar heat plant Dorkwerd
	Action description	Establishment of the largest solar heat plant in the Netherlands, connection to the Warmtestad heat grid
	Field of action	Energy systems
Implementation	Responsible bodies/person for implementation	Novar/K3
	Primary target	Generation of 78000 GJ heat
	Secondary targets	Reduction of CO2
	Involved stakeholders	Novar, K3, Warmtestad, municipality,
	Comments on implementation – consider mentioning resources, timelines, milestones	The park is being completed and is expected to be operational in Q4 2024
Impact	GHG emissions reduction estimate (total) per emission source sector	-
	Avoided GHG emissions by generation of renewable energy.	4680 Ktons CO2 eqv in Energy systems

Individual action outlines

Action outline	Action number	9
	Action name	restwarmte datacenters Zernike

	Action description	Use the residual het of 2 datacenters on the Zernike Science Park as heat source for Warmestad Heat grid
	Field of action	Energy systems
Implementation	Responsible bodies/person for implementation	Warmtestad, datacentre owners
	Primary target	Feed in of 10.000 Weq= 300000GJ residual heat
	Secondary targets	CO2 reduction
	Involved stakeholders	Warmtestad, datacentre owners, municipality
	Comments on implementation – consider mentioning resources, timelines, milestones	Completed.
Impact	GHG emissions reduction estimate (total) per emission source sector	
	Avoided GHG emissions by generation of renewable energy.	18000 KTon CO2 eqv

Individual action outlines

	Action number	10
Action outline	Action name	Zonneparken
	Action description	Built and production of locally owned large scale solar parks
	Field of action	Energy systems

Implementation	Responsible bodies/person for implementation	Municipality, developers, local energie coops
	Primary target	200MWp PV by 2025
	Secondary targets	CO2 reduction, financial stream to Energy transition fund, biodiversity
	Involved stakeholders	Municipality, Grunniger Power coop, Energie coop Ten Boer, Bronnen van Ons, Ecorus,
	Comments on implementation – consider mentioning resources, timelines, milestones	Park Roodehaan, 22 Ha, negotiations on purchase by municipality, park Meerstad Noord in development (200MWp), Westpoort Noord (in design), Fledderbosch (in production, 94 Ha) Woldjerspoor waste depot: 65.000 panels .
Impact	GHG emissions reduction estimate (total) per emission source sector	
	Avoided GHG emissions by generation of renewable energy.	25600 KTon CO2 eqv

Individual action outlines		
Action outline	Action number	11
	Action name	Zon op het dak
	Action description	Stimulation of PV installations on privately owned buildings
	Field of action	Energy systems
Implementation	Responsible bodies/person for implementation	Building/homeowners

	Primary target	425 MWp by 2030
	Secondary targets	CO2 reduction
	Involved stakeholders	Building/homeowners, installation branche, municipality (permitting and subsidy-advice)
	Comments on implementation – consider mentioning resources, timelines, milestones	For many homeowners, the subsidy possibilities are ample: national subsidy ISDE, local subsidy for energy improvement as part of compensation for earthquake damage, and a netting scheme: the use of electricity is netted with the production of energy at the same price. As a consequence, PV on roofs has become so popular, that local gridlocks and grid-instability occur, and energy providers are demarketing PV by raising the costs of feeding in electricity. Average payback period is 5 years, so it is a no regret measure
Impact	GHG emissions reduction estimate (total) per emission source sector	
	Avoided GHG emissions by generation of renewable energy.	54400 Ktons CO2 eqv
Individual action outlines		
Action outline	Action number	12
	Action name	Groningen stroomt door
	Action description	Mitigation of electric gridlock and net congestion
	Field of action	Energy systems

Implementation	Responsible bodies/person for implementation	Enexis, TenneT, Municipality
	Primary target	No net-congestion asap, power available for all necessary actions
	Secondary targets	
	Involved stakeholders	Enexis (low and medium voltage), TenneT (national high voltage) municipality (permitting, planning), province of Groningen (coordination and planning over several municipalities). The net congestion will affect almost every stakeholder in the transition
	Comments on implementation – consider mentioning resources, timelines, milestones	Easing net congestion is first priority for the municipality, because it threatens the development of our municipality. It is also key for the transition towards a low-carbon energy system. Several levels of action: lobby towards Enexis and TenneT, in order to raise priority, cooperation with Enexis in planning operations in public space, cooperation with Enexis in redesigning the mid-voltage grid in a smart way, urban planning for giving space to 755 new low voltage transformers, 13 Ha of mid-voltage stations, new mid-voltage powerlines and many kilometres of underground low voltage powerlines. Coordination and advice to enterprise in smart use of the grid: sharing connections, planning of demand and supply, smart dimensioning of connections. The completion of a much needed high-voltage extension is planned for 2031 (barring legal appeals, which are likely). The grid-provides face net congestion in the whole of the Netherlands, face very high investments and a lack of human power to implement. A special municipal taskforce has been installed to speed up planning, permitting

		and design. A group of coaches are supporting companies with smart grid solutions
Impact	GHG emissions reduction estimate (total) per emission source sector	-
	Avoided GHG emissions by generation of renewable energy.	-
Individual action outlines		
Action outline	Action number	13
	Action name	Gemeentelijk Energie Bedrijf
	Action description	Funding of a municipal energy company, in order to ensure that local production of energy leads to local use of the profits.
	Field of action	Energy systems
Implementation	Responsible bodies/person for implementation	municipality
	Primary target	Keeping the gains of local production into the local system
	Secondary targets	
	Involved stakeholders	municipality
	Comments on implementation – consider mentioning resources, timelines, milestones	The Gemeentelijk Energie Bedrijf has been founded (limited company 100% owned by municipality). The net profits will flow into the Energy Transition Fund. The GEB will own and manage solar parks and possibly wind parks
Impact	GHG emissions reduction estimate (total) per emission source sector	-

	Avoided GHG emissions by generation of renewable energy.	-
Individual action outlines		
Action outline	Action number	14
	Action name	Groningen afvalvrij 2030
	Action description	Policy to reduce the non-reusable part of household-waste to 0 kg, raise the recyclable partition of waste, and use the remainder for energy production
	Field of action	industry
Implementation	Responsible bodies/person for implementation	Municipality
	Primary target	0 kg non-reusable waste in 2030
	Secondary targets	CO2 reduction, production of biogas and biofuels, production of heat and electricity, reduction of scope 3 emissions, reuse of materials
	Involved stakeholders	Municipality (collection, regulation, first sorting of waste, purchase of waste treatment capacity), Omrin (waste treatment provider)
	Comments on implementation – consider mentioning resources, timelines, milestones	Extensive policy of waste reduction. Groningen municipality is responsible for waste collection and does this by her own organisation. Sorting is partly done upfront (compostable waste, small chemical waste, large volume waste, paper/cardboard, glass and other waste) Most waste is sorted in a central production facility of Omrin, which proves to be more efficient and results in better quality of reusables.

		First step is reduction of waste, second step is better sorting, last step is better industrial processes for reuse and energy production. All usable fractions are sorted out, reused if possible, the remainder is used as much as possible for energy production. A remaining fraction is now still being incinerated, but from 2026, a new plant will be able to use this fraction also (pyrolysis). In 2023 70% of the waste was used, leaving 102kg per household to be incinerated, which saved 12621 KTon CO2 eqv The potential of energy from waste is 102.573 MWh per year, of which 3.600.000 m3 green gas, 53.657 MWh heat and 16.171MWh electricity.
Impact	GHG emissions reduction estimate (total) per emission source sector	10649 Kton CO2 eqv
	Avoided GHG emissions by generation of renewable energy.	12622 KTon CO2 eqv
Individual action outlines		
Action outline	Action number	15
	Action name	Groningen werkt slim
	Action description	platform for sustainable business Groningen, advice for businesses on energy use, better efficiency of industrial processes
	Field of action	industry
Implementation	Responsible bodies/person for implementation	Municipality

	Primary target	Reduction of energy use
	Secondary targets	CO2 reduction, easing net congestion
	Involved stakeholders	Municipality (advice, permitting, supervision, enforcement), industry, associations of business parks
	Comments on implementation – consider mentioning resources, timelines, milestones	Advice for companies on smarter and better use of energy and transition towards more sustainable processes. This is combined with the legal duties and obligations: permitting and enforcement. Expected result is a decrease of energy use of 6.1 %
Impact	GHG emissions reduction estimate (total) per emission source sector	15077 Kton CO2 eqv
	Avoided GHG emissions by generation of renewable energy.	

Individual action outlines

	Action number	16
Action outline	Action name	Uitstoot vrije zone
	Action description	Closing off the inner-city for freight logistics and commercial vehicles with ICE engines in 2025
	Field of action	mobility
Implementation	Responsible bodies/person for implementation	municipality
	Primary target	Reduction of emissions

	Secondary targets	air quality, health, pedestrian and bike friendly, quality of inner city, less noise
	Involved stakeholders	Municipality (regulation, planning, enforcement), logistics sector (new mode of transportation (cargo bike, new forms of EV, conversion of trucks and vans to EV or H2, use of cargo hubs and multi modal transportation), businesses in the inner-city (shared mobility with EV's, using hubs for better efficiency)
	Comments on implementation – consider mentioning resources, timelines, milestones	From 2025 the municipality will declare an emission free zone for commercial traffic in the inner city. This will be enforced by ANPR.
Impact	GHG emissions reduction estimate (total) per emission source sector	1000
	Avoided GHG emissions by generation of renewable energy.	

Individual action outlines

	Action number	17
Action outline	Action name	Emission free public transportation
	Action description	All public transport will be converted to emission free techniques by 2030
	Field of action	mobility
Implementation	Responsible bodies/person for implementation	Public Transport providers (QBuzz, Arriva, NS), OVBureau Groningen
	Primary target	Zero emission from public transport in 2030
	Secondary targets	air quality, quality of life, less noise

	Involved stakeholders	Arriva, QBuzz, NS, (all providers of PT), OV Bureau Groningen/Drenthe (licensing and procurement of PT), municipality, province (partners in OV Bureau)
	Comments on implementation – consider mentioning resources, timelines, milestones	Already al train transport is zero emission, NS by using sustainable electricity, Arriva by using HVO. Public bus transport in the city is mostly EV and H2, all busses are to be converted by 2030 to EV or H2. PT providers are also planning to make their assets (stations, workshops, garages) CO2 neutral by 2030, and are reducing energy consumption
Impact	GHG emissions reduction estimate (total) per emission source sector	37.680 KTon CO2 eqv
	Avoided GHG emissions by generation of renewable energy.	

Individual action outlines		
Action outline	Action number	18
	Action name	EV strategy
	Action description	Promotion of the use of EV, public charging infrastructure, H2-filling stations, fleet ownership municipality
	Field of action	mobility
Implementation	Responsible bodies/person for implementation	municipality
	Primary target	Reduction of emissions
	Secondary targets	850 charging points in 2025, 6000 charging points in 2040, 16000 ev's in 2025, 160 EV for municipal fleet in 2025, 70 charging

		points in municipal buildings, 20 H2 municipal trucks and cars in 2025, fleet emission free in 2035, CO2 reduction, noise reduction
	Involved stakeholders	Municipality, car owners
	Comments on implementation – consider mentioning resources, timelines, milestones	Municipality chose to do the management of public charging points by herself, because of the impact on the use of public space. The contract with a managing company was stopped, because the focus point of this company was ROI instead of public value. Electrification of cars id in full swing, but net congestion is a threat. At this moment, fast charging stations are commercial activities, and there is no grid capacity to add fast charging stations. The municipal fleet is being converted to EV. Groningen is involved in European projects for trying out H2 trucks.
Impact	GHG emissions reduction estimate (total) per emission source sector	See action 19
	Avoided GHG emissions by generation of renewable energy.	

Individual action outlines

Action outline	Action number	19
	Action name	Groningen Goed op Weg
	Action description	Mobility program: 4 action programs: doorwaadbare stad (Getting away from car logic), 'walking, biking and road safety', 'Hubs' and 'shared mobility'

	Field of action	mobility
Implementation	Responsible bodies/person for implementation	municipality
	Primary target	A more sustainable mobility system
	Secondary targets	CO2 reduction, traffic safety, impact on public space, noise reduction, reduction of pollution. Air quality, quality of life
	Involved stakeholders	Municipality (design public space, permitting, incentives, promotion, parking taxation), car users, bikers, pedestrians, PT.
	Comments on implementation – consider mentioning resources, timelines, milestones	A comprehensive program to transform the mobility sector. Key is the idea that the car should not be dominant in public space. This means redesign of public space (less space for cars, lowering max speed, more space for bikes and pedestrians, using shared mobility solutions, and implementing a logic of multi-modal transport, with different kind of nodes inside the city and on the outskirts. Already, Groningen is the most bicycle intensive city in Europe, arguably in the world. The concept is the 15-minute city, where any transport movement by bike, on foot or by PT is 15 min or less, but movements by car will take longer. Groningen is participating in several European funded projects in mobility.
Impact	GHG emissions reduction estimate (total) per emission source sector	5168 Kton CO2 eqv
	Avoided GHG emissions by generation of renewable energy.	

5.4.2 Pathways

Table 19 List of pathways

Number	***category***	***name***	***CO2 reduction (Kton CO2 eqv per year)***	***CO2 avoided (KTon CO2 per year)***
1	built environment	retrofitting measure 28, 29	97029	
2	built environment	Warmtenet connecting homes	26185	
3	built environment	Warmtenet connecting commercial real estate	18348	
4	built environment	Thermal energy storage systems		
5	built environment	isolation of non-residential buildings	38021	
6	energy systems	restwarmte West Groningen	36000	
7	energy systems	residual heat Eemshaven		
8	energy systems	solar parks		81000

9	energy systems	solar thermal parks		30000
10	energy systems	wind power		4608
11	energy systems	biofuels	pm	
12	industry	conversion of industrial heat		
13	mobility	EV personal cars		
14	mobility	emission free freight logistics		
15	mobility	leidraad openbare ruimte	0	0
		Total	215583	132188

Table 20 Detailed descriptions of pathways

		Individual pathway outlines
	Action number	1
Pathway outline	Action name	Retrofitting measure 28, 29
	Action description	Isolation of all households to energy standard, complete gas free installation of homes that need to be rebuild.
	Field of action	Built environment
Implementation	Responsible bodies/person for implementation	National Government
	Primary target	Compensation for damages due to earthquakes
	Secondary targets	Energy reduction, CO2 reduction, combatting energy poverty, restoring damaged trust in government
	Involved stakeholders	National government (funding), municipalities (planning, management of district approach), province (coordination), SNN (subsidy agency), homeowners, installation and construction companies
	Comments on implementation – consider mentioning resources, timelines, milestones	As compensation for the damages due to gas-mining induced earthquakes, the national government is funding a program for compensation. Measure 28 and 29 are designed to bring all household to an isolation standard of 57KW/m2, aka as gas-free ready. For this a fund of 1.6 billion euros has been formed, plus a fund for management and execution of the program. For the municipality of Groningen, about 1 billion Euro will be available for isolation. This makes retrofitting homes financially viable. However, the execution is a different matter, the sheer volume of work to be done and materials to be used is unheard of.

		Estimated is that just 15% of the workload can be done by local businesses. Target is completion of the program by 2035
Impact	GHG emissions reduction estimate (total) per emission source sector	97029 Kton CO2 eqv
	Avoided GHG emissions by generation of renewable energy.	

Individual pathway outlines

	Action number	2
Pathway outline	Action name	Warmtenet connection to households
	Action description	Further enlarging the heat grid to homes
	Field of action	Built environment
Implementation	Responsible bodies/person for implementation	Warmtenet, municipality
	Primary target	Connect 35% of all households to the heat grid
	Secondary targets	CO2 reduction
	Involved stakeholders	Warmenet (heat grid operator), municipality (licensing, planning), social housing corporations (launching customer), homeowners
	Comments on implementation – consider mentioning resources, timelines, milestones	The current plans are connecting some 21.00 homes. However, to reach our climate targets, we need to connect more homes, a calculated 35% of all households. This means about doubling the size of the current plans.

		No concrete plans have been made yet. It also means that Groningen might look into different temperatures for the grid and a ring duct around the city, in order to connect multiple districts and multiple heat sources. Estimated timeframe 2030-2035
Impact	GHG emissions reduction estimate (total) per emission source sector	26185 Kton CO2 eqv
	Avoided GHG emissions by generation of renewable energy.	

Individual pathway outlines		
Pathway outline	Action number	3
	Action name	Warmtenet, connection to commercial real estate
	Action description	Further enlarging heat grid to commercial real estate
	Field of action	Built environment
Implementation	Responsible bodies/person for implementation	Warmtenet, Municipality
	Primary target	Connecting 50% of SME's in 2035
	Secondary targets	CO2 reduction
	Involved stakeholders	Warmenet (heat grid operator), municipality (licensing, planning), real estate owners
	Comments on implementation – consider mentioning resources, timelines, milestones	In the current plans, some commercial real estate is connected. However, to reach our targets, it is calculated that we should connect 50% of the businesses. This is a substantial enlargement of the heat grid,

		towards industrial and commercial parks. It also means that Groningen might look into different temperatures for the grid and a ring duct around the city, in order to connect multiple districts and multiple heat sources. Estimated timeframe 2030-2035
Impact	GHG emissions reduction estimate (total) per emission source sector	18348 Ktons CO2 eqv
	Avoided GHG emissions by generation of renewable energy.	

Individual pathway outlines

	Action number	4
Pathway outline	Action name	Thermal energy storage systems
	Action description	storage of heat and cold in businesses
	Field of action	Built environment
Implementation	Responsible bodies/person for implementation	Commercial real estate owners
	Primary target	50% of all businesses
	Secondary targets	CO2 reductions, energy savings
	Involved stakeholders	Commercial real estate owners
	Comments on implementation – consider mentioning resources, timelines, milestones	Since the heat grid will not be able to provide enough heat for businesses, it may be necessary that businesses should use a heat/cold storage facility, either individual, or as a group of businesses.

Impact	GHG emissions reduction estimate (total) per emission source sector	To be calculated
	Avoided GHG emissions by generation of renewable energy.	

Individual pathway outlines

	Action number	5
Pathway outline	Action name	isolation of non-residential buildings
	Action description	Better isolation of commercial real estate
	Field of action	Built environment
Implementation	Responsible bodies/person for implementation	Building owners
	Primary target	30% reduction of the need of energy for heating in commercial real estate
	Secondary targets	CO2 reductions, energy savings
	Involved stakeholders	Building owners
	Comments on implementation – consider mentioning resources, timelines, milestones	Currently, there is no obligation, or incentive-program to isolate commercial real estate, other than an obligation to reach certain energy ratings for offices. The economic driver for isolation of commercial real estate is yet weak, return on investment may take decades. However, from the point of view of our targets, a reduction of the consumption of energy of these buildings is needed

Impact	GHG emissions reduction estimate (total) per emission source sector	38021 Ktons CO2 eqv
	Avoided GHG emissions by generation of renewable energy.	

Individual pathway outlines

	Action number	6
Pathway outline	Action name	restwarmte West Groningen
	Action description	Use of residual heat from industry in the Western part of Groningen
	Field of action	Energy systems
Implementation	Responsible bodies/person for implementation	warmtenet
	Primary target	600.000 GJ heat feed into the heat grid (2030)
	Secondary targets	CO2 reduction
	Involved stakeholders	Warmtenet (management heat grid), municipality (planning, coordination, permitting) Industry, especially COSUN
	Comments on implementation – consider mentioning resources, timelines, milestones	In order to have enough sustainable heat for the current plans (22.000 households), we need the residual heat from industry in the Western part of Groningen. This hinges very much on the plans and cooperation of Cosun, a very large sugar factory (part of ETS). This plan is also planning to boost efficiency, thus using residual heat for their production process. This may hinder plans for feeding in this residual heat source into the grid.

Impact	GHG emissions reduction estimate (total) per emission source sector	36000 Tons CO2 eqv
	Avoided GHG emissions by generation of renewable energy.	

Individual pathway outlines

	Action number	7
Pathway outline	Action name	Eemspijp
	Action description	Construction of a heat pipeline from Groningen Seaports (Eemshaven) to Groningen, in order to use residual heat from industry
	Field of action	Energy systems
Implementation	Responsible bodies/person for implementation	National government
	Primary target	Construction of heat pipe 2035
	Secondary targets	CO2 reductions
	Involved stakeholders	National government (funding, part of groningen compensation scheme) province and municipalities Hogeland, Eemsdelta, Groningen (coordination, planning, licensing), industry (provision of residual heat
	Comments on implementation – consider mentioning resources, timelines, milestones	In the Eemshaven, some 40 km from Groningen, is a large concentration of industry: power plants, datacentres, heavy industry. The residual heat of this industry is not used yet. It may be necessary as sustainable heat source for groningen and a number of villages along the route of the pipeline. It has been proposed to fund the pipeline from the compensation funding for

		earthquakes. No formal decisions have been made.
Impact	GHG emissions reduction estimate (total) per emission source sector	To be calculated
	Avoided GHG emissions by generation of renewable energy.	

Individual pathway outlines

	Action number	8
Pathway outline	Action name	PV Solar parks
	Action description	Adding more large-scale PV parks
	Field of action	Energy systems
Implementation	Responsible bodies/person for implementation	municipality
	Primary target	500MWp PV in 2035
	Secondary targets	CO2 reduction
	Involved stakeholders	Municipality (planning, licensing, possibly operations by municipal energy company)
	Comments on implementation – consider mentioning resources, timelines, milestones	To reach climate neutrality, the planned PV parks are not enough, Groningen needs more. This may be done of agricultural areas, also helping in cutting emissions
Impact	GHG emissions reduction estimate (total) per emission source sector	

Avoided GHG emissions by generation of renewable energy.	81.000 Kton CO2 eqv

Individual pathway outlines		
Pathway outline	Action number	9
	Action name	solar thermal parks
	Action description	Additional solar thermal parks as sustainable heat source
	Field of action	Energy systems
Implementation	Responsible bodies/person for implementation	municipality
	Primary target	166MWth capacity in 2035
	Secondary targets	CO2 reductions
	Involved stakeholders	Municipality (planning, possibly operations by municipal energy company)
	Comments on implementation – consider mentioning resources, timelines, milestones	Groningen needs source for sustainable heat. Additional sola heat capacity may be needed
Impact	GHG emissions reduction estimate (total) per emission source sector	
	Avoided GHG emissions by generation of renewable energy.	30.000 Kton CO2 eqv
Individual pathway outlines		
	Action number	10

Pathway outline	Action name	Wind power
	Action description	Construction of 3 large wind turbines
	Field of action	Energy systems
Implementation	Responsible bodies/person for implementation	municipality
	Primary target	36MWp wind power
	Secondary targets	CO2 reductions
	Involved stakeholders	Municipality, province
	Comments on implementation – consider mentioning resources, timelines, milestones	In the RES it was understood that the municipality of Groningen would be allowed to construct large wind turbines. This is still the wish of the municipality. However, the permitting authority, the province of Groningen, has had a political change, and more wind on land is in the view of the province unwanted. Though a site for 3 wind turbines has been selected, discussions between province and municipality continue
Impact	GHG emissions reduction estimate (total) per emission source sector	
	Avoided GHG emissions by generation of renewable energy.	4608 Ktons CO2 eqv
Individual pathway outlines		
Pathway outline	Action number	11
	Action name	Biofuels
	Action description	Replacement of fossil fuels by biofuels
	Field of action	Energy systems

Implementation	Responsible bodies/person for implementation	unknown
	Primary target	Replacement of 100% of remaining fossil fuels by biofuels in 2035
	Secondary targets	CO2 reduction
	Involved stakeholders	unknown
	Comments on implementation – consider mentioning resources, timelines, milestones	After al actions and pathways, there will remain fossil fuels (gas, automotive) to be replaced by biofuels, which are almost climate neutral. This implies a large footprint in terms of use of agricultural land. Groningen will need to import these biofuels, which means that other areas will need to export them.
Impact	GHG emissions reduction estimate (total) per emission source sector	pm
	Avoided GHG emissions by generation of renewable energy.	

Individual pathway outlines

	Action number	12
Pathway outline	Action name	conversion of industrial heat sources
	Action description	Heat sources for industry need to be converted from gas to sustainable sources
	Field of action	industry
Implementation	Responsible bodies/person for implementation	Industry, municipality
	Primary target	50% electric heating, 25% biomass by 2035

	Secondary targets	CO2 reduction
	Involved stakeholders	Industry as problem owner, municipality (permitting, enforcement)
	Comments on implementation – consider mentioning resources, timelines, milestones	Many industrial processes still run on natural gas. In 2035 these processes should mostly be converted to sustainable sources: electric heating or use of biofuels.
Impact	GHG emissions reduction estimate (total) per emission source sector	To be calculated
	Avoided GHG emissions by generation of renewable energy.	

Individual pathway outlines		
Pathway outline	Action number	13
	Action name	EV for personal use
	Action description	Conversion of cars for personal use to EV
	Field of action	mobility
Implementation	Responsible bodies/person for implementation	Car owners, EU
	Primary target	90% of personal cars are EV
	Secondary targets	CO2 reduction, air quality
	Involved stakeholders	Car owners, EU for regulations, national governments (fiscal arrangements)
	Comments on implementation – consider mentioning resources, timelines, milestones	In order to curb the emissions form personal vehicles, we need to switch to EV's, and we need to reduce the number of kilometres by car.

		The average use of a car for personal use is 19 years in the Netherlands, so action should be taken immediately, in 2023, 30% of new cars in the Netherlands were EV.
Impact	GHG emissions reduction estimate (total) per emission source sector	16.580 Kton CO2 eqv
	Avoided GHG emissions by generation of renewable energy.	
Individual pathway outlines		
Pathway outline	Action number	14
	Action name	Emission free logistics
	Action description	conversion toward electric or emission free heavy traffic
	Field of action	mobility
Implementation	Responsible bodies/person for implementation	Fleet owners, EU, national government
	Primary target	100% of freight transport in 2035, of which 50% H2,40% bio-LNG,10% EV
	Secondary targets	CO2 reductions, air quality, less noise
	Involved stakeholders	Fleet owners, EU (regulations), national government (fiscal arrangements)
	Comments on implementation – consider mentioning resources, timelines, milestones	Freight logistics, especially for long haul, is hard to tackle. Heavy vehicles do not easily convert to battery-operation. A mix of EV and sustainable fuels will be needed

Impact	GHG emissions reduction estimate (total) per emission source sector	Pm
	Avoided GHG emissions by generation of renewable energy.	
Individual pathway outlines		
Pathway outline	Action number	15
	Action name	Leidraad openbare ruimte
	Action description	Implementation of our design guide for public space
	Field of action	mobility
Implementation	Responsible bodies/person for implementation	Municipality
	Primary target	Climate adaptation
	Secondary targets	CO2 reduction, less car usage, more space for bikes and pedestrian, increasing traffic safety, improving air quality, improving biodiversity, quality of life
	Involved stakeholders	Municipality (management of public space
	Comments on implementation – consider mentioning resources, timelines, milestones	Groningen introduced in 2023 the Leidraad openbare ruimte, a guide on how to design public space. This means for different roads different profiles, but all with less space for cars, more space for green and water retention, more space for biking, walking and recreation. This guide will be implemented wherever redesign of public space will be done, but it comes at an extra financial burden, for which the budgets are limited. Groningen is looking into the possibility to use the

		savings on combined project planning (heat grid, sewage, electricity grid) for finance of the implementation of the guide
Impact	GHG emissions reduction estimate (total) per emission source sector	pm
	Avoided GHG emissions by generation of renewable energy.	

5.5 Indicators for Monitoring, Evaluation and Learning

The municipality of Groningen has yet to make steps in ensuring that our policies and actions are being monitored for the purpose of evaluation, adjustment and learning.

Evaluation of our policy documents (see Appendix A) shows that in general our policies do not have many quantifiable and measurable goals. We have few systems in place that ensure monitoring and feedback. Feedback on policies and actions is often done in qualitative terms, monitoring is mostly done in terms of completion of projects, instead of effects of projects on a goal. Feedback loops are generally 4-6 years, which is not adequate for the sake of the mission.

A telling example is the roadmap to CO2 neutrality 2035. This roadmap was developed in 2017, decided on in 2018. The next formal revision was planned for 2023, and this started with taking the CO2 inventory. At this moment, the revision of the roadmap is still underway, the formal decision on this is expected to be in fall 2024. This is a revision cycle of 6 years, which is to long for a mission towards 2030!

The municipality of Groningen now has procured a contract for monitoring emissions on a yearly basis for the next 3 years. This monitor will provide the mandatory indicators: CO2 emissions for Energy systems, Built Environment, Industry, Mobility and Agriculture/Land Use.

These CO2 emissions are, of course, not measured directly, they are modelled from indirect data (proxies) from many sources. Many of these sources are not on city level, but on national level. Modelling CO2 emissions is not straight forward. Different models will result in different numbers, even with the same data sources.

Currently, we use the Berenschot-monitor for purposes of monitoring CO2 emissions for reporting. We use the Energy Transition Model for purposes of modelling the impact of our actions and designing pathways towards net zero.

In cooperation with the national government, Groningen is in the early stages of implementing the model of Climate View. This is a pilot from the national government to see if it is possible to set open standards for modelling and monitoring.

Setting indicators based on proxies for CO2 emissions provide endless opportunities, but limited information that is usable to manage towards desired outcome. This is also the case with indicators for monitoring related systems, such as social interventions. Building a model on more proxies, that may be interdependent and based in multi-causality does not improve the value of the model.

There may be correlation and even causality between indicators and goals, but very often, exogenous influence is larger than the influence of our actions. For example: we could provide traffic accident data such as #injuries and #death. However, these data are more influenced on the use of bicycle helmets and weather than by decreasing car traffic.

The effort and cost of monitoring is proportional to the number of indicators, Groningen therefore proposes to keep it simple. We will report on the GHG emissions, as it is mandatory and the ultimate goal. This monitoring system is already in place.

We will report on a limited number of other indicators, which are strictly based on the priorities in our policies: the change in built environment towards sustainable heating with a heat grid, the local generation of energy from solar and wind, combatting energy poverty and inequality, abandoning car logic in the city and decreasing household waste.

Table 21 List of indicators

Indicator #	Sector	Strategic priority	indicator	Target
1	Energy	Reduction of GHG	Kton CO2 eqv/year (modelled)	Mandatory indicator

				Net 0 Kton in 2035 for all sectors
2	Energy	Local generation of sustainable energy	GWp PV installed large scale solar parks	500 GWp in 2035
3	Energy	Local generation of sustainable energy	GWp Wind installed large scale	36 GWp in 2035
4	Energy	Local generation of sustainable energy	MWh production per year of PV small scale roof mounted	383 GWh in 2035 (based on 450GWp PV solar and factor 0,85 MWH per MWp)
5	Built environment	Changing to sustainable heating	# connections to heat grid	40.000 households in 2035
6	Built environment	Changing to sustainable heating	GJ sustainable heat sources into heat grid per year	682890GJ in 2030
7	Built environment	Changing to sustainable heating	Total energy use for households	decrease
8	mobility	Abandoning car-logic in the city	% Modal split pedestrian/bike/car/public transport for trips inside the city	decrease of car use, no specific target specified yet
9	Mobility	Abandoning car-logic in the city	% Modal split pedestrian/bike/car/public transport for trips to and from the city	decrease of car use, no specific target specified yet.

10	Industry	Decreasing non-recyclable or reusable household waste	Kg non-recyclable or reusable household waste per household per year	0 Kg in 2030
11	Other	Combatting (energy-)poverty and inequality	# households in poverty	No specific target

Table 22 Detailed description of indicators

	Indicator Metadata
Indicator #	1
Indicator Unit	KTon CO2 eqv per year
Definition	See definition in section GHG Baseline Inventory
Calculation	Modelled, see section GHG Baseline Inventory
Does the indicator measure direct impacts (reduction in GHG emissions?)	yes
If yes, which emission source sectors does it measure?	Required for all sectors
Does the indicator measure indirect impacts (i.e., co- benefits)?	no
Expected data Source	Monitor CO2 by Berenschot, based on CBS-data
Is the data source local or regional/national?	mixed
Expected availability	Available, contracted for 3 years

Suggested collection interval	yearly

Indicator Metadata

Indicator #	2
Indicator Unit	MWp PV installed in larger scale solar parks
Definition	MWp of PV installed in solar parks> 200m2
Calculation	Sum of MWp of the installed panels
Does the indicator measure direct impacts (reduction in GHG emissions?)	yes
If yes, which emission source sectors does it measure?	Energy systems
Does the indicator measure indirect impacts (i.e., co- benefits)?	no
Expected data source	Building permits and construction plans
Is the data source local or regional/national?	local
Expected availability	Data available, but not publicly accessible yet
Suggested collection interval	yearly

Indicator Metadata

Indicator #	3
Indicator Unit	KWp Wind installed large scale
Definition	KWp wind installed on turbines > 20m axel height

Does the indicator measure direct impacts (reduction in GHG emissions?)	yes
If yes, which emission source sectors does it measure?	Energy systems
Does the indicator measure indirect impacts (i.e., co- benefits)?	no
Expected data source	Building permits / construction plans
Is the data source local or regional/national?	local
Expected availability	Theoretically available, but no wind power installed yet
Suggested collection interval	yearly

Indicator Metadata

Indicator #	4
Indicator Unit	GWh electricity produced by PV in households (roof mounted PV)
Definition	Total energy use households (incl PV behind meter) minus electricity delivered to households
Does the indicator measure direct impacts (reduction in GHG emissions?)	yes
If yes, which emission source sectors does it measure?	Energy systems
Does the indicator measure indirect impacts (i.e., co- benefits)?	no
Expected data source	Aggregated data from smart

Is the data source local or regional/national?	local
Expected availability	Available through Regional Klimaatmonitor (input CBS)
Suggested collection interval	1 year

Indicator Metadata

Indicator #	5
Indicator Unit	# connections to heat grid
Definition	Number of connections to the Warmtestad heat grid
Does the indicator measure direct impacts (reduction in GHG emissions?)	Not direct but indirect
If yes, which emission source sectors does it measure?	Built environment
Does the indicator measure indirect impacts (i.e., co- benefits)?	no
Expected data source	Report from Warmtestad B.V. (grid owner) based on billing information
Is the data source local or regional/national?	local
Expected availability	yes
Suggested collection interval	yearly

Indicator Metadata

Indicator #	6
Indicator Unit	GJ sustainable heat sources into heat grid per year

Definition	GJ feed from sustainable sources per year
Does the indicator measure direct impacts (reduction in GHG emissions?)	yes
If yes, which emission source sectors does it measure?	Built environment, energy systems
Does the indicator measure indirect impacts (i.e., co- benefits)?	no
Expected data source	Report from Warmtestad bv (grid owner)
Is the data source local or regional/national?	local
Expected availability	Not yet available in yearly rapport, should be available from 2024 on
Suggested collection interval	yearly

Indicator Metadata

Indicator #	7
Indicator Unit	total energy use for households
Definition	Sum of yearly energy use of households in Groningen (TJ)
Does the indicator measure direct impacts (reduction in GHG emissions?)	yes
If yes, which emission source sectors does it measure?	Built environment
Does the indicator measure indirect impacts (i.e., co- benefits)?	no
Expected data source	CBS data (energy use households per municipality), based on smart meters and reports from energy providers, CBS data average size

	household per municipality, based on Cadastral information
Is the data source local or regional/national?	Localized data, collected by national statistics service
Expected availability	available
Suggested collection interval	Yearly

Indicator Metadata

Indicator #	8
Indicator Unit	% Modal split pedestrian/bike/car/public transport for trips inside the city
Definition	Relative size of transport mode in traveler-kilometers per year for trips inside the municipality
Does the indicator measure direct impacts (reduction in GHG emissions?)	No, indirect
If yes, which emission source sectors does it measure?	mobility
Does the indicator measure indirect impacts (i.e., co- benefits)?	Yes: indirectly health, traffic safety, traffic-pollution and noise, quality of life
Expected data source	Traffic measurements and sensors, reports from Public Transport, possibly data from navigation providers and mobile phone data (Google environmental Insights)
Is the data source local or regional/national?	local
Expected availability	Partly available, Google Environmental Insights only available for the city and not for the totality of the municipality
Suggested collection interval	yearly

Indicator Metadata

Indicator #	9
Indicator Unit	% Modal split pedestrian/bike/car/public transport for trips to and from the city
Definition	Relative size of transport mode in traveler-kilometers per year for trips to and from the municipality
Does the indicator measure direct impacts (reduction in GHG emissions?)	No, indirect
If yes, which emission source sectors does it measure?	Mobility
Does the indicator measure indirect impacts (i.e., co- benefits)?	Yes: indirectly health, traffic safety, traffic-pollution and noise, quality of life
Expected data source	Traffic measurements and sensors, reports from Public Transport, possibly data from navigation providers and mobile phone data (Google environmental Insights)
Is the data source local or regional/national?	local
Expected availability	Partly available, Google Environmental Insights only available for the city and not for the totality of the municipality
Suggested collection interval	yearly

Indicator Metadata

Indicator #	10
Indicator Unit	Kg non-recyclable or reusable household waste per inhabitant per year
Definition	KG of household waste that is non-recyclable or reusable, divided by the number of inhabitants

Does the indicator measure direct impacts (reduction in GHG emissions?)	yes
If yes, which emission source sectors does it measure?	industry
Does the indicator measure indirect impacts (i.e., co- benefits)?	no
Expected data source	Sensor data weighing of waste, billing data waste retrieval services, (billing) data waste processing factories
Is the data source local or regional/national?	local
Expected availability	available
Suggested collection interval	yearly

Indicator Metadata

Indicator #	11
Indicator Unit	# households in poverty
Definition	Number of households with household income < 120% legal minimum income. A new national definition is expected in 2024
Does the indicator measure direct impacts (reduction in GHG emissions?)	no
If yes, which emission source sectors does it measure?	
Does the indicator measure indirect impacts (i.e., co- benefits)?	Yes, indication of social problems, indication of capacity to invest in energy transition, indication of health and education level
Expected data source	Poverty per municipality, national Bureau of Statistics (CBS)

Is the data source local or regional/national?	Localized national source
Expected availability	yearly
Suggested collection interval	yearly

Table 23 Baseline indicators

Indicator #	indicator	Baseline value	Baseline year	Source:
1	Kton CO2 eqv/year (modelled)	Energysytems: 315.08 Kton Built environment: 339.53 KTon Industry: 265.02 KTon Agriculture/land use: 104.21 KTon Mobility: 278.69 KTon	2020	CO2 monitor Berenschot
2	MWp PV installed large scale solar parks	Not available yet		
3	KWp Wind installed large scale	0 KWp	2023	

4	GWh electricity produced by PV in households	34.6 GWh	2023	Regionale klimaatmonitor
5	# connections to heat grid	4707 small usage connections users, 28 large usage connections	2023	Warmtestad
6	GJ sustainable heat sources into heat grid per year	Not yet available		
7	Total energy use for households	4107 TJ	2023	Regionale Klimaatmonitor
8	% Modal split pedestrian/bike/ car/public transport for trips inside the city	12%pedestrian 38% bike 44% car 4% Public transport 2% motorcycle	2023	Google environmental insights (rounded at full percentages)
9	% Modal split pedestrian/bike/ car/public transport for trips to and from the city	0% pedestrian 2% bike 71% car 3% bus 24% train 0% motorcycle	2023	Google environmental insights (rounded at full percentages)
10	Kg non-recyclable or reusable household waste	111 kg	2022	Stadsbeheer Groningen

	per inhabitant per year			
11	# households in poverty	26.600 households	2022	Sociaal Planbureau Groningen

6 Part C – Enabling Climate Neutrality by 2030

6.1 Governance Innovation Interventions

In Groningen, we strongly believe that the transitions need to be based on 'lokale uitvoeringskracht' (local executive power). That is, that the local community should take action. It is part of our cultural heritage of 'Naoberschap', the tradition of depending on the help of neighbours. Within this tradition, the municipality acts as a neighbour. An important neighbour with considerable organisational and financial power.

So, while it may seem that the municipality of Groningen takes the lead in the transition, it is based on participatory processes.

6.1.1 Based in society

The fundament of our climate neutrality policies, the 2018 Roadmap CO2 neutral 2035, was designed in a process with many stakeholders. It resulted in the co-signing of this roadmap by 43 partners responsible for 40% of the Groningen emissions (see https://www.groningenCO2neutraal.nl/#modal-%2Fenergieakkoord-2). The co-signers are organised in the Platform Groningen CO2 Neutral. The partners in the Platform CO2 Neutral are from government, businesses and societal organisations.

Amongst the partners in the transition are the social housing corporations. These are non-profit and regulated organisations with the goal to provide affordable housing (rental). These social housing corps are key in our efforts to decarbonize homes, as they are owner of some 31% of all housing. With these corporations, the municipality has made binding agreements on decarbonizing and connecting to the heat grid. Their housing will act in many cases as launching customer for the heat grid, thus enabling private homeowners to join.

Another key group of stakeholders are the homeowner associations (HOA), responsible for the upkeep of multi-owner buildings (apartment buildings). Some 40% of all housing is managed by a HOA. These HOA's vary from large and professional, to very small and non-professional. For the HOA's, who are responsible for the upkeep of walls, roofs and communal areas, financing retrofitting is hard, because most finance possibilities are property-bound instead of building-bound. This means that a majority (often 75%) of the members need to vote for retrofitting, and if the vote is positive, all owners need to invest, whether they have access to capital or not. It may be clear that this situation leads to hesitation to invest, and possibly to poverty or even forced eviction. A municipal team for support to these HOA's has been instated, providing both information and

services to groups of HOA's and inhabitants, and support to individual HOA's. The municipality also actively lobbies for a better legal framework to help HOA's.

This is not the only formal agreement on the transition towards climate neutrality. Another important agreement is the 'Akkoord van Groningen' (The Groningen Alliance). This is an agreement between the University of Groningen, the Hanze UAS, the University Medical Hospital Groningen, The Municipality of Groningen, the province of Groningen, the Martini Hospital, the Noorderpoort Vocational college and the Alfa Vocational college, to cooperate on the strategic development of the city. These partners represent the largest employers of Groningen, the educational sector, the medical sector and government. One of the partners, the UMCG, is among the top 5 CO2 emitting organisations in Groningen and is legally required to take part in the ETS-system.

The partners of this alliance pool together upfront resources to be able to do projects in common interest. The energy system has been one of the focus points of the Akkoord since the beginning in 2005. The partners agreed in the last revision of the Alliance, to be champions in Energy transition, in Health, Digitalisation and Emerging sectors, among which climate adaptation is mentioned.

The cooperation between the partners led to world-class research and education in the field energy transition, development of Hydrogen-technology and energy-management. It is through the combined effort of the Alliance partners, that the Global Centre of Climate Adaption, an UN-funded organisation, has settled in Groningen.

In 2023, the municipality committed a survey amongst the signees to feel if there is support for a mission goal of 2030. Though most signees are trying to accelerate their efforts, in general they felt that a 2030 goal is not within the realm of possibilities. Commercial parties added that accelerating to an even more ambitious goal could endanger their competitiveness and financial stability.

6.1.2 Participation

Participative processes are engrained in Dutch society. The Netherlands would not have been shaped to its current form if without participation in combatting water. You can't build a system of dykes, levies, and waterways without working together, and maintaining this system together.

Nowadays, the culture of participation has a legal base. For any process that shape the living environment of our inhabitants, there are legally required participatory processes. Failing to oblige to these legal requirements will result in legal action either privately, or by governmental organisations.

The Groningen politics have a longstanding tradition of insisting on good participatory processes, beyond the legal requirements. Groningen even has had local referenda, which is quite rare in Dutch society.

One of the prime examples of the high standard of participation is the Groningen bylaw on Participation for larger scale solar and wind-projects (https://gemeente.groningen.nl/file/participatiekader-voor-zonne-en-windparken). This bylaw strictly zones solar and wind-parks, requiring from the initiating party the execution of a formal participation plan, the establishing of a fund for the immediate surroundings, contracts for compensation of loss of quality of living and local ownership of at least 51%.

The building of a heat grid, and the connection of homes to this grid has profound implications for those inhabitants involved. The municipality has taken a lot of effort in participation and information of those involved. Numerous meetings in those neighbourhoods have been organised, even the use of ice cream and coffee carts to involve the inhabitants has been done. But the municipality has noted that in those meetings, you will not reach all inhabitants. Especially the vulnerable and marginalised groups can't be reached by group meetings.

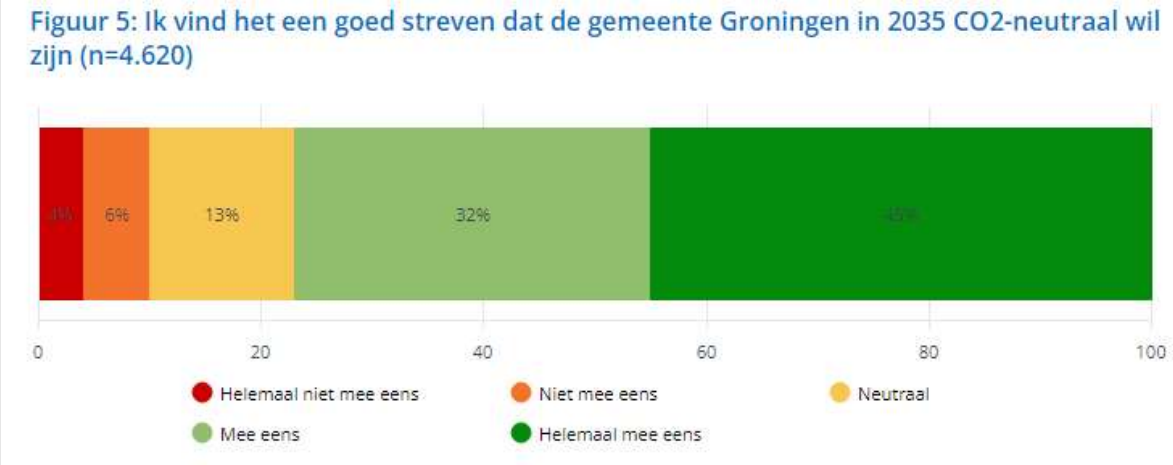
That is why the municipality decided to approach the inhabitants of vulnerable neighbourhoods in a different way. In those streets and neighbourhood teams approach the inhabitants a door-to-door. These teams are a mix of energy coaches and social workers. The conversation starts with offers to help with the transition to gas-free: isolation, connection to the grid, for which the municipality can offers subsidy, loans and guarantees, making it affordable and risk-free for the inhabitant. Often, this is also an entrance for talking about social issues, such as poverty, health, education and employment. Though this approach is very labour intensive, it is also successful. Though reaching 100% is impossible, we do reach some 90% of the people. The success is not only in terms of the number of people that agree to retrofit their homes, but also a success for the social services in terms of reaching people that they would otherwise not reach.

The municipality is looking into new ways of participation in the field of climate mitigation. In cooperation with the Groningen University, a PhD-researcher has been employed (50/50 paid for by the municipality) to do research into the most efficient ways to involve our inhabitants.

In the Horizon-financed project Making City, the Hanze UAS has developed tools for participation in the energy transition, these tools are used by the municipality.

In late 2023, the municipal Bureau of Statistics polled the opinion of inhabitants with regards to climate neutrality in 2035. The poll was (partly) answered by 4.662 participants, most from our city panel (4.304) but also through an open link, published in traditional and social media (358 participants).

The whole poll can be seen (in Dutch) online: https://publicaties.oisgroningen.nl/routekaart-groningen-CO2-neutraal.



Green = agree, red = disagree

Figure 19 respondents agreeing with the goal of 2035

Some 77% of the respondents agree fully, or to some extend in setting the goal for 2035. The reasons to set climate goals are varied, but 'green' reasons are dominant: care for nature (important for 93%), combatting climate change (important for 88%). Lowering energy costs follows (83%). But also stopping with Russian gas (78%) and the end of mining gas from the Groningen field (71%) are surprisingly often named to be important reasons to set goals. Comfort in homes and peer-pressure are felt to be of less importance.

On the question of who is responsible for acting on climate neutrality, the reactions were quite even: inhabitants themselves, municipality, companies, province and national government all scored high, international action though not one of the named alternatives, was also frequently mentioned.

Of the respondents, 65% reported to have taken small actions for isolation, 50% said to have taken major actions, and 37% reported to have changed their methods of travelling.

In general, there seems to be popular support for the actions that the municipality proposes, even though the respondents are aware of negative effects and spatial implications of those actions.

The respondents were also asked how they wanted to become involved by the municipality. Some 22% did not want to be involved in any way, 36% wanted to be informed, 15% wanted to be able to express their opinions, 13% wanted to have the right to decide themselves and 13% did not know or had no opinion.

Participation is guaranteed by laws and bylaws, but most certainly it is guaranteed by our democratically elected municipal council. The municipal council consists of 45 members representing 12 political parties. The council is legislative: it is responsible for deciding on budget, strategic policies, and local bylaws and regulations. It also checks the executive power (the board of the Mayor and Vice-Mayors). The council itself has no executive powers. Active and passive voting rights for the council are for all (legal) inhabitants of Groningen if they are 18+. This includes all EU-citizens and for those who originate from outside the EU, a minimum legal stay of 5 years is needed. The Groningen municipal council has a strong history on insisting that municipal planning is rooted in participatory processes.

6.1.3 Governance within the municipal organisation

The executive power is formed by the board of the Mayor and Vice-Mayors (het college van Burgemeester en wethouders). Currently, there are 8 vice-mayors, each responsible for their own fields of policy, but decisions are exclusively made by the totality of the board (collegiaal bestuur), within the mandate set by the municipal council. The board is mostly proposed by a majority coalition within the council, board members are not allowed to be council members and can be required to resign by the council. The Groningen city council is very diverse, from environmentalists to very conservative, from national to local parties. The majority of the Groningen council is progressive, and has been so since the 1970's, with very wide support for climate mitigation.

The board will set the ambitions for the 4-year period between municipal elections, of course on the condition of approval by the municipal council. These ambitions are

translated into policies and actions. The board will ask the municipal management team to form these policies and actions and to execute these actions. The management team will comply, if the requests fit within the possibilities of budgets and capacity.

The municipal management team consists of 4 people: the municipal secretary-general and CEO, a director for spatial affairs, a director of social affairs and a director of internal organisation. The management team also decides as a team.

The municipality employs about 5000 people, or 3300 ftu. The municipal organisation is divided into directorates (headed by a director) and departments (headed by a head of department) and teams (headed by team leaders). This is mostly a hierarchical division, but also a division into function and policy areas, with its own budget lines. But policy areas may also be managed through a programmatic approach, with often, but not always, separate budget lines.

This makes for a complex and opaque governance on issues that are cross-cutting the organisation, such as climate mitigation. Climate mitigation as such is not one of the responsibilities of a vice-mayor. Energy, Mobility and Housing are, just as Internal Organisation and city-management.

The main body of climate mitigation is done in the Energy program (some 85 people, with a separate budget), but there are strong links to the programs of Mobility and Housing and to the program Quality of Life, which is mainly responsible for climate adaptation planning. City Planning, City Management and Economy are directorates, Real Estate management is a department.

It has been recognized that the organisational structure of the municipality is struggling to cope with the societal challenges ahead. Currently, new structures and development of the organisation is being contemplated by the municipal management board.

The complexity of the organisation is mirrored by the financial structures. Budgets may or may not be earmarked by directorates or programs. Add to this the very complex system of how a Dutch municipality is financed: lump sums, earmarked budgets, regional, national and European subsidies, special programs, specific target finance, city-deals, national programs, and for a very small part, local tax (property tax, parking tax and tax on commercial signage).

Notable is that CO2 reduction, or climate mitigation is not mentioned as the prime target of most programs and policies. Even the Energy program, under which the roadmap to CO2 neutrality falls, is focussed on the energy system (sustainable, affordable and reliable), and less focussed on emissions. The targets mentioned in the policy documents are very diverse, and include themes like road safety, abandonment

of car-logic, circularity, less waste, no poverty, better health, more biking etc. These targets are mostly not quantified.

It is fair to remark that the municipal organisation can improve on governance of climate mitigation. This will also be remarked in the chapter on Outlook and Next Steps.

6.1.4 Multi-Level Governance

From the onset of the Mission 2030: 100 Climate Neutral and Smart Cities, it was clear that the cities can't reach climate neutrality without cooperation on different levels of government. The original ideas even suggested that the City Climate Contract should be also signed by the member states and the European Commission, thus ensuring unwavering commitment to the mission. Groningen was one of the cities that advocated that idea. Alas, this ideal will remain unfulfilled for the time being. Nevertheless, cooperation between the different levels of government is important and it has been taken up for the Dutch Mission cities.

In the Netherlands, each level of government has a large degree of autonomy. There is no hierarchical relationship between the different levels. Of course, each level of government has to act within the law, and they may depend on other levels for finance and functions.

The municipality of Groningen is located in the province of Groningen. For the mission, there are interfaces between the province and the municipality. All regions (and in this case the region is the province of Groningen) are required to have a Regional Energy Strategy (RES). This RES has been described in the paragraph on regional policies. In terms of energy system, the municipality of Groningen needs the region, for import of electricity (wind and solar), for importing heat from the Groningen Seaport area and for the production of biofuels. The province of Groningen is also important for planning and licensing infrastructure (such as high-voltage grids) across the administrative boundaries of municipalities.

There are good direct lines of communication between the province and the municipality. The province of Groningen is also signee of the Roadmap Groningen CO2 Neutral 2035.

The mission has had positive impact on the relations between the Dutch Mission Cities and the national Dutch government. After the start of the mission, the Dutch Mission cities (Amsterdam, Rotterdam, Utrecht, Den Haag, Eindhoven/Helmond and Groningen) and the ministries of Interior, Economy and Infrastructure and Water Management convened to set up a National Support Structure (NSS) for the transition towards net zero. With the mission cities piloting for all Dutch cities, the NSS will try to clear

(regulatory and organisational) roadblocks towards net zero, and mainstream knowledge on the transition to all Dutch cities and municipalities. The first roadblocks that are being tackled are on bio-based building, neighbourhood approach and heat grids and zero-emission zones for mobility. Bi-weekly meetings ensure that the process of forming the NSS will go smoothly.

As to the involvement of the European Commission: The EC supports the mission of course, mainly through financing the NetZeroCities-consortium. This consortium is a valued knowledge partner, but it cannot be directly involved in implementing actions that lead to climate-mitigating.

Groningen acknowledges that the Mission is a new mechanism and is still evolving. Steps are being made to give more substance to the mission. The formation of the Cities Mission Mayors Advisory Group is a step forward towards cooperation on an equal footing. We also see that more substance is added to the Mission label. However, Groningen feels that the mission cities are taking extra risks and are making extra costs in being the forefront of the transition towards net zero, A lack of direct support on European level will make it difficult for cities to keep fulfilling this role and may endanger the Mission.

6.2 Social Innovation Interventions

The mission for climate neutrality is not just about reduction of GHG emissions. It has profound implications for society.

The Groningen municipality is acutely aware of the societal effects. In fact, most of the goals in our policies and most of the goals of the board of the Mayor and Vice-Mayors are stated in terms of societal effects and not in terms of GHG reductions.

The goals of this ‘coalitie akkoord 2022-2026' are to ensure wellbeing, respect for people and animals, security in existence, quality of living environment and liveability of the planet. These values are deeply engrained in the Groningen society.

A lot of emphasis is being placed on inclusiveness and affordability for all people of our transition plans. The war in Ukraine showed that this was necessary, as the gas prices soared, it had direct impact on the quality of life of those that were in poverty, or in danger of getting into poverty. Direct financial aid from the national government helped. But Groningen is not a rich society. There is a gap between the highly educated, with high income, good health, excellent employability and longer life-expectancy and those

who are less educated, with less income, lower health, lower employability and years of less (healthy) life expectancy.

This gap has been noted years ago, and Groningen is in the forefront of cities that try to mitigate this gap.

The energy transition is a perfect example of the systemic disadvantages of the less fortunate group. To a large extend, they live in homes with insufficient build quality, insufficient isolation and old installations. This leads to higher costs of energy use. Because they can't afford these costs, they are forced to turn down the heating in cold times. This leads to problems with moisture, moulds, health problems, which leads to less availability for work or education, etc.

6.2.1 Neighbourhood approach

A few neighbourhoods tend to have a larger number of people living in these conditions. These neighbourhoods also tend to have a higher number of social problems: violence, abuse of substances, neglection or abuse of children etc. For social services it is hard to reach these groups. Much of the problems are playing in private space, and these groups tend not to be involved in public events. Reaching out to them is hard, people tend to distrust government, also due to some scandals in social security in the Netherlands.

In Groningen we try to break this cycle with our neighbourhood approach. The municipality has identified the districts where these problems are prominent. We prioritize these neighbourhoods for interventions in the built environment: isolation and connection to the heat grid. While we open up the streets for these interventions, we also use it to upgrade the sewage (climate adaption), and to redesign public space to new standards: more greenage, more room for pedestrians and bikers, more room for recreation, green heatsinks for refuge in heatwaves. We'll take the public space away from cars and give it back to people.

Of course, many people can't afford retrofitting their homes. We cooperate with the social housing corporations to prioritize the retrofitting of rental homes in these areas, and because their business case is to provide social housing, this will not lead to increase of rental fees. For private homeowners, there are many opportunities to get subsidy (sometimes up to 100%), loans, and grants. We aim to raise the quality of all houses in a street to the same level, so there is uniformity, and there is no difference in appearance between rental homes, private homes of those who can afford retrofitting and those who can't afford it.

The approach of the inhabitants is by mass meetings in the neighbourhood at first but will lead to a finer approach if needed. In some streets, teams will literally go door-to-door. The teams, consisting of an energy coach and a neighbourhood worker, will offer a complete and tailored package: finance, isolation, connection to the heat grid, turn-key solutions. Because the teams are not asking anything but are offering a deal, the uptake is very good. Most 'knocks on doors' will lead to a 'kitchen-table' conversation with the inhabitants. And most of these conversations will lead to a plan for isolation and connection to the heat grid.

Once this line of communication is opened, it is also open for other social interventions: help with debts, with work or education, with care. This means that the municipal employees working in these teams must develop a good knowledge of not just energy, but they need to develop excellent social skills and a good knowledge of the social system in Groningen.

The physical interventions in the homes will lead to better health and lower energy bills, which means that income can be freed for better food and other necessities, thus lowering the risk of poverty.

The redesign of public space, which is carried out while implementing a heat grid and sewage renewal, will lead to a healthier and more active lifestyle. People will spend more time in public space, will walk, bike and play more, and the social adhesion will grow stronger. It has even impact on the food system, there is space for small gardens and fruit bearing trees.

Of course, it is early days. Monitoring wellbeing and health will take many years. In Groningen one of Europe's largest research projects on lifestyle and health is taking place, Lifelines. This project is a longitudinal research project over generations and looks into both the effects of nature and nurture of the Groningen population on health. The results of the Groningen interventions in these neighbourhoods are being monitored by Lifelines and other programs.

6.2.2 Healthy mobility

Another typical Groningen approach is the mobility approach. Mobility is key for a good social life but may be prohibitively expensive for some groups. There are clear links between mobility and health.

The Groningen approach is saying goodbye to the logic of using cars. To be fair, in the Netherlands, since the 70's, cars have been less dominant in public space than in other countries. The Netherlands are flat, ideal for biking. Groningen divided the city centre in 1973 in 4 sections. These sections did not communicate by car, if one were to go from

one section to another, one would need to circumnavigate the centre. Gradually this was built out to a most car free city centre in the 2000's.

Groningen now uses the concept of the 15-minute city. The idea is that any travel within the city by bike, on foot or by public transport should be doable within 15 minutes. Going by car will take longer. Groningen has invested in an excellent biking infrastructure. Most inhabitants own more than 1 bike, and these bikes are used as a full mode of transport, not just for recreational use.

Figure 20 A Groningen bicycle light (050 is the Groningen area code)

Groningen invested in PT-hubs on the outskirts of the city. Park your car there, take a cheap ride into town, or change to a bike. Apart from the national system of OV-bikes, there is no bike-sharing system for bikes, because they are so easily available. Electric scooters are available but regulated.

New are the plans for redesign of public space. If Groningen redesigns a street, prevalence will be given to taking back public space from the cars: less street, less parking, reduced speeds, more greenery, more biking and walking space, more space for recreation.

The remaining car traffic should be mostly EV (no noise and pollution) and should share sparce and expensive parking spaces. This means that car ownership is less attractive. The car is a liability in the city, not an asset. Shared mobility is more attractive: a shared EV should be available within walking distance, and shared EV's will get priority in parking and charging.

The results of these policies should not just be a reduction of emissions. It will lead to a shift towards biking and walking. This is cheap (freeing up income), healthy (physical activity) lead to less pollution and more social interaction. It may lead to less injury due

to traffic accidents, though that is debatable: the Netherlands see an increase in serious accidents with electric bikes. Public Transport will be emissions free. For people with lower incomes, a free PT-pass is available.

6.2.3 Protein transition

Groningen is the first municipality in the Netherlands with a vice-mayor in charge of protein-transition. The idea behind the protein-transition is that we should eat more vegetable proteins, and less animal proteins.

Firstly, animal husbandry has impact on the environment. Cows, pigs and poultry are a source of emissions of GHGs and of NOx. Especially cattle are using lots of resources in terms of drinking water, available land use (not just meadows, but the use of intensive production of grass, corn and soy for feed) and energy (for tractors etc.).

The animal welfare is another source of worry, as is the risk of epidemics and pandemics due to monocultures and intensive husbandry. And vegetable proteins are associated with more healthy foods and lifestyle.

This is good reason to start a transition towards more vegetable protein. This transition is in early stages. It will look into the agricultural system (transition towards a more divers and vegetable protein rich crop instead of husbandry), it will look into our food distribution system (more local food, more emphasis on veggies in supermarkets) and it will look to the demand side: how do we consume food, and how can we change into a healthier lifestyle, for ourselves and our planet?

The potential societal gains are large. A smaller ecological footprint, healthier life (less obesity) and possibly cheaper local and seasonal food.

7 Outlook and next steps

In the process of making the CCC, a few striking observations can be made. The making of this CCC could be seen as a form of audit on our policies, very useful and sometimes frustrating. Though Groningen is very active in the transition towards climate neutrality, there is room for improvement.

It may also be noted that a new iteration of the Groningen Roadmap to CO2 neutrality is in the making and will be decided on by the city council in autumn 2024. In this new iteration, the goals, action and pathways will be aligned with our experiences and new insights.

Groningen will reiterate a new version of the CCC / CAP/ CIP in 2026 (2 years from now).

7.1.1 Policymaking

There are improvements possible in terms of our process of policy making. Groningen has plenty of policies; many of them are relevant. Some of them are inspiring and innovative. But in general, our policies tend to be descriptive. They tend not to lack quantifiable targets and goals. The policies often lack a system of monitoring, feedback and learning, aka the PDCA (Plan, Do, Check, Act) cycle.

The cycle of policymaking in Groningen varies, but on the whole a cycle of some 4 years is normal. This may be fine for normal situation, but in terms of a mission and the urgency of transition towards climate neutrality, 4 years is too long. It would be logical to work towards shorter cycles, with smaller incremental changes based on monitoring and feedback.

This would also help with the problem of synchronizing different fields of policies. Because climate mitigation is crosscutting different fields of policy, asynchronous updates of policies will hinder an integral approach.

It is also very hard to discern old policies and different versions form the authorised version. A quality insurance system is lacking, as is an online database with authorised policies.

The municipal organisation is currently starting up a program for organisational transformation. In this process, the observations on policymaking have been noticed and recommendations have been made to the Groningen management.

7.1.2 Governance

The municipal governance of climate mitigation is complex and opaque. This is blocking effective integral interventions. The municipal governance originated in times where the world was less complex, and projects could be carried out with a large degree on independency.

However, the world is changing, rapidly. The organisational structure is not a good answer for the grand societal challenges we are facing. This has been noted and will be addressed in the evolution of the organisation. Already bottom-up initiatives are starting, such as coordination tables between the different policy programs.

An organisational change will go hand in hand with a cultural change. These processes take time but have been noted and are being addressed.

7.1.3 Mission orientation

As noted in the previous section, Groningen is very much project oriented and not mission oriented. There is still a discussion on the nature of the mission: are we doing it to please the outside world, or is it a new instrument for improvement of our efforts towards climate neutrality? This is also a matter of governance: which model do you choose to deal with the large transitions that we see ahead?

The period towards a next iteration of the CCC will be used to discuss this matter, and to choose a model of transition.

8 Appendices

Appendix A: Report Energy Transition Model

Appendix B : List of policy documents

Appendix C: Joint statement of the Dutch cities on climate neutrality targets

Appendix D: Response to remarks by the JRC on the Groningen CCC (sept 2024)

Appendix A: List of Policy Documents

Meerjarenprogramma stadsontwikkeling 2023-2026	https://gemeenteraad.groningen.nl/Vergaderingen/Politieke-woensdag-Dag-agenda/2023/12-april/10:00/Meerjarenprogramma-Stadsontwikkeling/Meerjarenprogramma-s-Stadsontwikkeling-2023-2026-1.pdf
Meerjarenprogramma stadsontwikkeling 2022-2025	https://gemeenteraad.groningen.nl/Documenten/Bijlage-Meerjarenprogramma-s-Stadsontwikkeling-2022-2025.pdf
• Warmtetransitieplan Groningen 2022-2030 (2021)	https://gemeenteraad.groningen.nl/Vergaderingen/Politieke-woensdag-Dag-agenda/2021/27-oktober/09:30/Bijlage-Warmtetransitieplan-2022-2030-Uitvoering-warmtetransitie-2.pdf
• Beleidskader zonneparken 2021-2025 (2021)	https://gemeenteraad.groningen.nl/Vergaderingen/Politieke-woensdag-Dag-agenda/2021/27-oktober/09:30/Bijlage-1-Beleidskader-Zonneparken-gemeente-Groningen-2021-2025-2.pdf
• Beleidskader zon op daken 2021-2025 (2021)	https://gemeenteraad.groningen.nl/Vergaderingen/Politieke-woensdag-Dag-agenda/2021/27-oktober/09:30/Bijlage-1-Beleidskader-Zon-op-daken-gemeente-Groningen-2021-2025-2.pdf
• Regionale Energie Strategie 1.0 (2021)	https://resgroningen.nl/over+de+res/achtergrondinformatie/handlerdownloadfiles.ashx?idnv=1990181
• Uitkomsten Windverkenning (2021);	https://gemeenteraad.groningen.nl/Vergaderingen/Politieke-woensdag-Dag-agenda/2021/14-april/10:00/Uitkomsten-Windverkenning-1.pdf
• Gebiedsvisie Meerstad-Noord (2021);	https://gemeenteraad.groningen.nl/Vergaderingen/Politieke-woensdag-Dag-agenda/2021/07-april/10:00/Gebiedsvisie-Meerstad-Noord-2.pdf
• Analyse ten behoeve van warmtebronnenstrategie Groningen (2020);	https://gemeenteraad.groningen.nl/Documenten/Bijlage-Rapportage-analyse-warmtebronnenstrategie-Groningen.pdf
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CO2 monitor 2023	https://gemeenteraad.groningen.nl/Documenten/CO2-monitor-oktober-2023-en-actualisatie-Routekaart-stand-van-zaken.pdf
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• Vervolg definitief investeringsvoorstel Warmtenet Noordwest (2019);	https://gemeenteraad.groningen.nl/Documenten/Vervolg-definitief-investeringsvoorstel-Warmtenet-Noordwest-75871-2019-combi-juni-2019-bijlagen-zie-aldaar.pdf
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Routekaart Groningen afvalvrij 2030	https://gemeenteraad.groningen.nl/Documenten/Bijlage/Bijlage-2-Routekaart-Groningen-afvalvrij-2030-versie-2.pdf
Mobiliteitsvisie Groningen Goed op weg	https://gemeente.groningen.nl/file/mobiliteitsvisie-groningen-goed-op-weg
Uitvoeringsplan doorwaadbare stad	https://gemeente.groningen.nl/file/uitvoeringsprogramma-doorwaadbare-stad
Uitvoeringsprogramma-lopen-fietsen-en-verkeersveiligheid-2023-2030	https://gemeente.groningen.nl/file/uitvoeringsprogramma-lopen-fietsen-en-verkeersveiligheid-2023-2030
Uitvoeringsprogramma deelmobiliteit	https://gemeente.groningen.nl/file/uitvoeringsprogramma-deelmobiliteit
Uitvoeringsprogramma hubs	https://gemeente.groningen.nl/file/uitvoeringsprogramma-hubs
Multimodaal Netwerkkader Groningen	https://gemeenteraad.groningen.nl/Documenten/Bijlage/Bijlage-2-Multimodaal-Netwerkkader-Kaartenboek.pdf
Beleidsplan Verkeerslichten Groningen	https://gemeenteraad.groningen.nl/Documenten/Bijlage-3-Beleidsplan-Verkeerslichten.pdf
Transitievisie Stap voor stap naar aardgasvrije wijke en dorpen 2019	https://gemeente.groningen.nl/file/stap-voor-stap-naar-aardgasvrije-wijken-en-dorpen-strategie-en-aanpak
meerjarenprogramma Energie 2020 - 2023 Groningen geeft energie 2020	https://gemeenteraad.groningen.nl/Documenten/Raadsvoorstel/Bijlage-1-MJPEnergie-2020-2023.pdf
Kaders-en-uitgangspunten-Fonds-energietransitie-en-gemeentelijke-exploitatie-duurzame-energie.pdf	https://gemeenteraad.groningen.nl/Documenten/Raadsvoorstel/Kaders-en-uitgangspunten-Fonds-energietransitie-en-gemeentelijke-exploitatie-duurzame-energie.pdf
Omgevingsvisie Levende ruimte 2022-2035	https://gemeente.groningen.nl/file/omgevingsvisie-levende-ruimte

routekaart eiwit en voedsel strategie	https://gemeente.groningen.nl/duurzaam-voedselsysteem
uitvoeringsagenda routekaart eiwit en voedsel strategie	https://gemeente.groningen.nl/file/uitvoeringsagenda-voedsel-en-eiwittransitiepdf
Energie transitiemodel 2024	https://pro.energytransitionmodel.com/scenarios/882495
Participatiekader zon en wind	https://gemeente.groningen.nl/file/participatiekader-voor-zonne-en-windparken
coalitie akkoord groningen 2022-2026	https://gemeente.groningen.nl/file/coalitieakkoord-2022-2026

Appendix B: Joint statement of the Dutch cities on climate neutrality targets

Summary

The Dutch mission cities are eager to realize the ambition of the 100 Climate-Neutral and Smart Cities Mission. While we remain committed to the Mission objectives, we also question the feasibility of achieving full climate neutrality by 2030 considering current systemic barriers, such as national policies, infrastructure constraints, labor market constraints and a (lack of) funding mechanisms. In this paper, we explain how stating a 2030 target might hinder our shared ambition and commitment to accelerate decarbonization. Furthermore, we will elaborate on our concrete actions and strategies to continue driving the climate transition and achieve meaningful carbon emission reductions despite these barriers.

Climate neutrality targets in the Dutch mission cities context

The 100 Climate-Neutral and Smart Cities Mission presents a unique opportunity for Dutch mission cities to accelerate their climate transition. Having received Climate City Contracts from most Dutch Mission cities, the European Commission has become aware that our cities are currently unable to commit to an at least 80% emissions reduction by 2030. While commitment is withheld, we want to underline our commitment to the mission goal of accelerating the climate transition.

We emphasize that in meeting the mission goal we face four barriers that cannot be overcome at the local level alone. The goal of this brief is to explain these barriers, outline the mitigating strategies we are undertaking, and clarify why addressing these barriers would improve the success rate of the mission.

1) Lack of Enabling Policy and Policy Freedom

Dutch cities work on the local level. While the local level is an inseparable part of the Dutch state, and thus legally responsible for meeting climate goals, municipalities often lack the necessary tools or legal mandates to implement the regulations and actions needed to achieve climate neutrality by 2030. Especially a facilitating national political level is crucial for success at a local level. A couple of factors would need to change to have Dutch municipalities succeed within the mission's timeframe. To illustrate this statement, we present the following examples:

- Dutch cities are politically constrained from implementing zero-emission zones for passenger vehicles. These are an essential tool to achieve the mission objective. Furthermore, even the zero-emission zones for logistics were heavily

debated at the national level, even though the zero emission logistics zones are a municipal competency and agreed upon several years prior.
- Dutch cities have gained the legal tools to enforce the phase-out of natural gas. They can do so after an eight-year period between notifying consumers of a phase out in a certain neighbourhood and actual decoupling from the natural gas grid after 2030. On a national level a bill is also being developed to shape the future heating market, requiring 51% public ownership of heating companies. Questions around how this ought to be best implemented result in large delays.
- Decarbonization of industrial actors is more of a provincial and national competency, achieved through the ETS, a national carbon tax, the industrial cluster energy strategies and multiple year programmes for climate and energy.
- The carbon intensity of electricity is calculated at the national level, which means that the phase out of, for example the Amsterdam Hemweg coal plant leads to carbon reductions that benefit all Dutch municipalities, but also that offshore wind counts as reducing carbon emissions within cities.

A key advantage of the mission for Dutch cities is increasing multi-level cooperation, with the commission and national government to accelerate the progress towards our shared goals. Structures like the national cooperation structure are ways to try and work towards bridging this issue. For the examples above, such multi-level platforms for deliberation might facilitate progress on these matters.

2) Large investment gaps

Dutch cities have limited capacity to carry risk via debt, as detailed in our investment plans. We also depend for a large part of our incomes on grants from the national government into the municipal fund and have very little legal room to levy taxes. These national grants which provide large parts of the budget are under pressure.

Moreover, the heating transition can require large investments from municipalities into district heating due to a national law being developed to make heating networks public infrastructure. Unclarity on how the bill for this law will be divided is causing delays in implementation. Large investments will also have to be made into public transit infrastructure, climate adaptation and decarbonization of our own assets.

One key objective of the mission is of course to bridge this gap. We are looking forward to seeing how we can use the available tools to help bridge our investment gaps.

3) Energy grid congestion

Large parts of the Netherlands currently face electricity grid congestion (Tennet, 2025): there is not enough transport capacity on different levels of the grid to ensure that all

consumers will be able to get connected and to ensure that decentralized electricity production can be transported towards the users.

For the transition to climate neutrality, the production, transport, and consumption of electricity needs to grow. Households that change to electric heating and an electric car can expect 3-5 times more electricity consumption. There is often not enough transport capacity on different voltage levels of the grid to ensure that all users will be able to get connected and to ensure that decentralized electricity production can be transported towards the users. This will increase the electricity grid congestion problem.

Furthermore, in parts of the country, including all mission cities, there is a waiting list to get connected to the grid, sometimes even for the new homes Europe sorely needs. The necessary investments in the main transport grid are underway. Permitting procedures and a global production shortage for essential parts, such as high-voltage transformers, add years to the process. Even without delays, depending on substation size, the process already takes 5-10 years.

Costs are also multiple times higher compared to five years ago due to material and production shortages. Current project timelines in the multi-annual investment frameworks for climate and energy make clear that this challenging situation will last until at least 2032.

Issues like the above limit the pace of decarbonization. Recognizing this, grid companies and governments are cooperating closely between government levels to accelerate grid investment and permitting, deployment of infrastructure and work towards smart grid solutions. Nevertheless, here too, the mission goals are under pressure.

4) **Labour shortages**

The Dutch labour market is tight and aging. The most recent data show that there are 106 vacancies for 100 unemployed people (CBS, 2024), with the highest shortages in so-called practical technical professions. This has consequences for the climate transitions. We use the city of Groningen as an example:

Unique in Groningen is that all necessary funding is available to insulate nearly all homes in the province. However, only 15% of the necessary human capital to is locally available. Groningen's original 7-year plan for this mega-operation cannot be met. Also in Groningen, nearly all investments of grid-operator Enexis have been delayed due to lack of workforce (Enexis 2023).

This shows that even if financial constraints are resolved, Dutch cities are still unable to accelerate to meet a 2030 target.

As these examples show, even if we were to have sufficient means and the necessary legal tools, large scale innovation on upscaling the deployment of renewable solutions will be necessary to fully achieve the city's mission. We are working to mitigate these barrier, for example with programs to reskill the labor force like Amsterdams program: “a job with a future”.

Risks of communicating and implementing a 2030 neutrality target

Given the barriers previously described, we believe the goal to claim that all Dutch cities can achieve climate neutrality by 2030 is infeasible. Moreover, holding an unrealistic target is in conflict with a city’s legal obligation of good governance. As it creates reasonable expectations from citizens concerning the pace of the transition that we cannot fulfill (informatiepunt leefomgeving, 2025).

Furthermore, to generate commitment and action of those not already involved in the climate transition, trust is pivotal. Trust, ultimately, comes down to reliability. A goal that has a known low likelihood to be achieved, but is nevertheless communicated to society at large, undercuts this trust in the long run. Cynicism and paralysis, instead of acceleration among stakeholders, might be the result.

In addition, municipalities in the Netherlands are subject to the European Convention on Human Rights (Hoge Raad, 2004). With the recent ECHR case against Switzerland local governments within the Netherlands may bear the same procedural responsibilities as national governments to:

- Set appropriate emission reduction targets,
- Prove they can achieve those targets or are on track to do so,
- Update targets to reflect best evidence and due diligence,
- Implement the necessary policies to meet them.

Because we judge that we cannot meet the 2030 target and currently lack the legal tools to implement the necessary policies, committing to this target may cause us to be in violation of the European Convention on Human Rights (European court of human rights, 2024).

Our commitment to the mission

When kicking off the mission in 2022, Frans Timmermans said: “This will be a massive challenge.” We understood this when we joined. We continue to believe in the necessity

and potential of the mission. We also firmly believe that we achieve our shared goals by continuing commitment to openness and a problem-solving attitude. We underscore that this must be reflected in our multilevel cooperation. Doing so helps us innovate, experiment and scale up together—across all levels of government—to drive breakthroughs.

This attitude is evident in how we collaborate through the national cooperation structure and the joint pilot in the mission. Under this structure, our cities and the national government strive to break or circumvent barriers that cities face, and have spent 2024 working on three themes:

- A neighborhood-based climate transition
- Sustainable mobility to and within cities
- Building bio-based

Building on the experiences from workshops and deep dives conducted jointly by cities and the national government, we will extend and deepen this cooperation in 2025. We want to work together to see how we can use the mission label to scale up the transition and what other joint steps we can take to increase the rate at which cities can achieve the transition. We will build and share knowledge on financial solutions, work towards achieving breakthroughs, for example on the topics of grid congestion and the heating transition whilst also connecting the mission to the national climate week to involve and share with our local and national stakeholders. This is how we will cooperate to resolve our four cornerstone issues.

Additionally, our climate action plans showcase the local-level measures we are already taking spanning beyond energy transition alone. By sharing this knowledge and experience through the Dutch Association of Municipalities in partnership with the Ministry of the Interior, we will help cities, the Netherlands and Europe become climate neutral.

We are fully committed towards that goal and continue to take large strides towards it. Even now, analysis from TNO states that our current action plans lead to a carbon reduction of roughly 22 Mton CO2e. Our commitment is even stronger: this number does not count our actions towards reducing consumption-based emissions and carbon storage through, for example, bio-based buildings which are a part of the mission to us.

Statement from the City of The Hague in support of the message of the Joint Statement made by the mission cities Amsterdam, Rotterdam, Utrecht, Groningen, Eindhoven and Helmond

The City of The Hague has communicated its ongoing commitment to the objectives of the 100 Climate-Neutral and Smart Cities Mission which is confirmed by our Climate City Contract. This commitment has been awarded with the Mission Label in October last year.

In comparison to other Dutch Mission Cities, The Hague is in a different position because the 2030 goal had previously been adopted by our city council in 2017. The Mission's climate neutrality ambition is hence aligned and act as extension of our local policy. Even though we have the official ambition of climate neutrality by 2030, we recognise and acknowledge all major challenges identified by the other Dutch cities as described in their Joint Mission Statement. We refer to the following: the lack of enabling policy and policy freedom, large/considerable investment gaps, electricity grid congestion, and labour shortages. We fully underline the analysis on these topics made by the other Dutch cities and will run into the same challenges when implementing the mission and its supporting policies and projects.

Since the start of the mission, all participating cities have invested in intensifying collaboration between the Dutch Mission Cities, which is strengthened by the Dutch Cities Pilot. The fact that the City of The Hague identifies the same challenges to meeting our shared climate objectives as the other cities means it is important that we continue collaborating on a national level. This is supported by the national government and formalised in the National Collaboration Structure.

Appendix C: Response to remarks by the JRC on the Groningen CCC (added Sept 5th 2025)

Introduction

Groningen submitted it's City Climate Contract in September 2024. Since, together with the cities of Amsterdam, Eindhoven, Helmond and Rotterdam, and supported by The Hague (which has received its mission label) and Utrecht (in process of delivering the CCC), we have had several constructive and meaningful discussions with representatives of the European Commission, the NetZeroCities consortium and the JRC.

This resulted in a response to the CCC Coherence and Completeness Checklist remarks by NZC for the Groningen CCC (March 2025) and a Joint Statement of the Dutch cities (March 2035), explaining the specific Dutch roadblocks that hinder the Dutch cities to reach netzero by 2030.

Since, more discussions with the representatives of these organizations followed, such as a discussion with the Mission management during the NZC conference in Vilnius.

As part of these discussion, the JRC gave some general and city-specific feedback, which would be useful to enhance the CCC's, and that would give the JRC better insight in a number of more technical and quantifiable details, making the CCC's comparable to other CCC's, and making them more useful as information input to the European Committee.

In this document, Groningen will try to answer those questions to the best of it's ability. Some of the requested information is available. However, the question of the JRC also (and rightfully so) tackles omissions, or thing we simply do not know yet. In case of omissions, Groningen intends to amend this the following revisions of the CCC.

Groningen wants to underline that we are fully committed to the EU's Mission 2030: 100 Climate Neutral and Smart Cities. We are committed to take all possible actions within our means and possibilities. To achieve the goals set out by the mission, we need the support and cooperation of other levels of government and of other actors. For Groningen, the mission is essential to enhance the support and cooperation and to jointly accelerate towards a climate neutral world.

Target formulation and emissions gap

The JRC asked for clarity on some issues about the emissions inventory and scope, especially about inclusions and exclusions and target formulation.

As a general remark: one of the learning points of making the CCC is that Groningen needs to strengthen it capacity in making data-driven policies. In June 2025, management has taken over this recommendation. We are recruiting 2 data-specialists especially for climate mitigation. This should result in better data, and alignment of data-sources and ultimately in better analysis. The future editions of the CCC should benefit from that.

The inventory and targets are for the whole administrative area of the Groningen Municipality. There are no geographical or other exclusions.

- All ETS facilities are included in the inventory. Officially, there are 4 ETS facilities in Groningen, counting for 188.518 Tons of CO2 per year (2024, source National Emission Authority). However, 2 of these facilities only have an administrative office in Groningen and no production facility: the Eems Energy Terminal is the headoffice of the LNG terminal in nearby Groningen Seaports (outside the administrative border of Groningen), and Solidus Solutions Board, with production facilities in the region and in 5 other countries (4 of which inside the EU). In our inventory, we count the official emissions, the factual local emissions are 136.863 Tons CO2 per year (2024).

  In our actions, we do not pursue ETS facilities actively, as they have there own pathways to CO2 neutrality. This does not mean that we don't interact with them. Our University Medical Centre, an ETS facility, is a key-client to our heat grid. Our sugar industry, another ETS facility, will provide residual heat to our heat grid. We are pleased to see that our factual ETS facilities are committed to the CCC, and that they have a planning to reduce their emissions to netzero. For the University Medical Hospital the horizon is netzero by 2035, which is a great feat, considering that this is the second largest hospital in the Netherlands, and that most activities are mission-critical to patientcare in the whole of the Netherlands and part of Northern Germany, which means that you can't shut them down for redesign/renovation.

- Scope 1 and 2 emissions (if applicable) for wastewater/waste within the administrative border of Groningen are fully included in the inventory. Scope 3 emissions for wastewater and waste are not included in the inventory, as they do not occur within the boundaries of the municipality. We do actively pursue the reduction of emissions (including scope 3) of this sector to netzero by 2030, even though

processing of waste is not being done inside the administrative border of Groningen. The Municipality is shareholder of a waste processing facility (elsewhere), thus has influence in reducing the emissions.

We intend to give an inventory of Scope 3 emissions of wastewater/waste in the next iteration of the CCC, as mitigating these emissions is part of our list of actions ('Groningen Wastefree 2030'). In this next iteration, more detailed quantitative data on the results of the actions should also be made available.

- Stationary and AFOLU emissions from the 6 sources (Forest and harvested wood products, Cropland, Grassland, Wetlands, Settlements and Other Landuse) are included in the inventory, confirming to the IPCC guidelines.
- Non-energy emissions from industry and chemicals (Groningen does not have a lot of industry) are included in the inventory. This includes all 13 known GHG's in scope 1 and 2.

Residual emissions:
In it's reduction targets, Groningen uses the same system as in the inventory: reduction compared to the 1990 levels, according to the standards of the IPCC.
So, in our 2030 target, we expect to reach a 60% reduction compared to 1990 of all emissions in the inventory. In 2035 we expect to reach a 80% reduction compared to 1990 of all emissions in the inventory, and we hope (but have no concrete plans yet) to compensate or to find extra pathways for the remaining 20%.
Groningen uses the term 'emissions gap' as intended: the gap between 100% reduction of all emissions in 1990 and the actual total emissions, regardless of level of influence of the municipality.
However, the level of influence is determining the actions of the municipality. We don't act primary on emissions we cannot influence, as we try to maximize efficient use of our limited resources and capacity. Of course, we do stimulate any action that would aid to mitigating these emissions, for instance by actively pursuing changes in national policies and regulations and stimulating initiatives from our inhabitants to act locally on global issues.
The focus of the CCC is necessarily mostly on reduction of GHG's emissions. In the narrative towards our inhabitants, however, the focus is on co-benefits, as CO2 emissions are, literally, invisible to people. In this narrative, where co-benefits such as health, equality, quality of life, safety and security etc. play, we do stimulate our inhabitants to locally do as much as possible, even on subjects that we don't have local influence on. Much of this effort is about behavioral influence, which hopefully will help to accelerate reduction of emissions outside our local influence.

For the sake of determining actions and predicting the total reduction of emissions, we do factor in the assumption, that levels of emissions will decrease, even if Groningen were to do nothing.

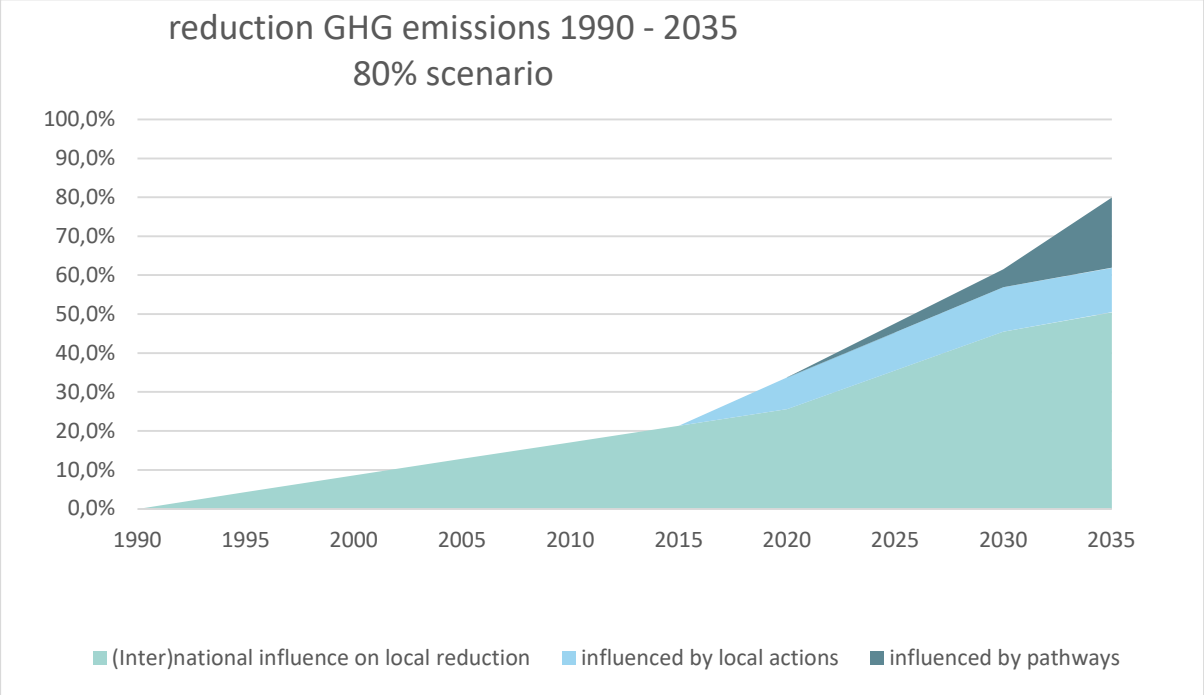


Figure 21 of CAP

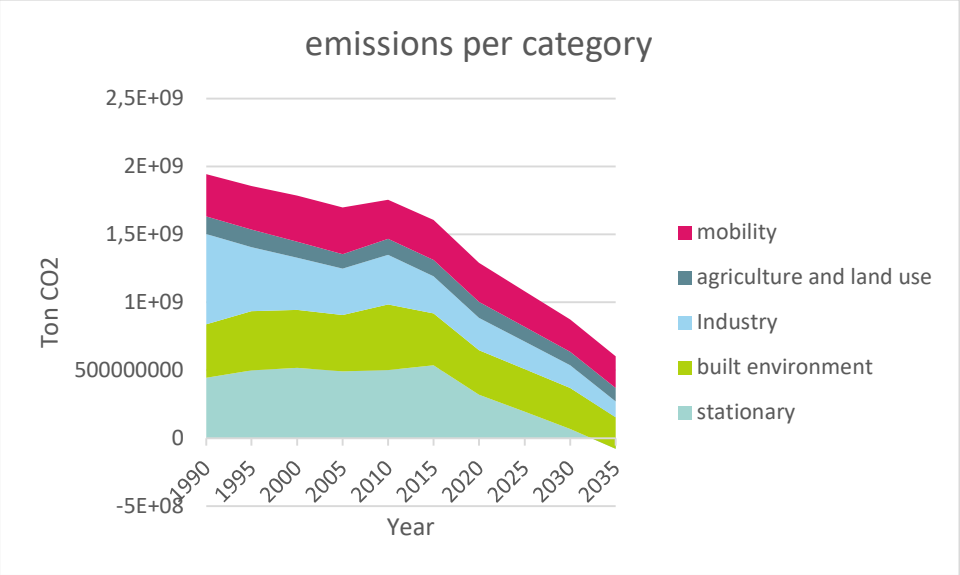
Table 24 reduction percentages of Figure 1

Emissions reduction	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
total	0,0%	4,3%	8,5%	12,8%	17,1%	21,3%	33,7%	47,6%	60,0%	80,0%
(Inter)national influence on local reduction	0,0%	4,3%	8,5%	12,8%	17,1%	21,3%	25,6%	35,6%	45,5%	50,5%
influenced by local actions	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	8,1%	9,8%	11,4%	11,4%
influenced by pathways	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	2,3%	4,6%	18,1%

Figure 1 of the CAP shows reduction over the years, with the effects of actions, pathways (as defined in our CCC) and 'autonomous' reduction. This graph shows 40%

residual emissions in 2030, and 20% residual emissions in 2035. As discussed later in this document, currently we do not have identified viable ways of further reductions or compensation, this needs to be tackled in revisions of the CCC.

Breakdown of emissions per category until 2035



percentual reduction	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
stationary	0%	-12%	-17%	-11%	-13%	-21%	28%	56%	85%	118%
Built environment	0%	-11%	-8%	-5%	-23%	3%	17%	20%	24%	41%
Industry	0%	29%	42%	48%	45%	59%	64%	70%	75%	83%
agriculture and landuse	0%	1%	10%	19%	10%	8%	10%	16%	22%	23%
Mobility	0%	-3%	-9%	-11%	7%	5%	8%	16%	24%	25%
Grand Total	0%	4%	8%	13%	10%	17%	34%	44%	55%	69%

The source of these numbers is the Berenschot inventory and their projections of the reductions based on their information. Note that the numbers do not add up to the projected 80% reduction in 2035. This is due to new actions, added after the date of inventory. Most prominent is the influence of 'Maatregel 29', our isolation program. Figure 1 of the CAP does reflect all quantified actions and pathways (sept 2024), but a breakdown into emission categories is not available. We intend to remedy this in the next iteration of the CCC.

Looking at figure 1 of the CAP, it may seem that Groningen is not committing as much as possible. Is Groningen doing enough? We pose that we all but maximize the opportunities that cities have to influence emissions. The majority of emissions are influenced on other scales than locally. We estimate that with our current CCC, we use 96% of the local strong and weak influence. Groningen certainly punches above it's weight in terms of capacity and funding for climate actions, with almost € 70 million per year committed from municipal budgets, and for the next 5 years more than € 1 Billion regional public funds committed and earmarked for the city to the Isolation Program. In our Energy program alone, some 80 people work on making our commitments happen, together with other programs and directions, we estimate some 150 of the 3300 full time employees of our municipality are working on climate mitigation and climate adaption.
We strongly advocate mitigation of emissions that we are not able to influence locally. We see that the Mission is a critical part in doing so: it enables cities to partner up with others in order to maximize their influence regionally, nationally and on European scale. The Dutch cities have partnered up with the national government and the Association of Dutch municipalities in order to be able to scale up the local actions and to jointly help in the European efforts to mitigate GHG emissions.

Residual emission strategy

As the JRC noted, there is still a gap between 100% climate neutrality and the projected reductions by 2030 and 2035. In this section Groningen will comment on that.

As noted in the introduction, the Groningen CCC contains only actions and plans that have been decided on and/or discussed by the democratic municipal council and the board of the mayor and vice-mayors.
When asking for ways to tackle emissions that have not been tackled in the CCC, the formal answer would be that we do not have policies for that, yet.
This does not mean, however, that policies, actions and pathways that have not been mentioned in the CCC, have not been considered.
Before the formal process of decision making on policies, much research has taken place. The conclusions of this research does not always reach publicity or formal decision making, especially when the conclusions are negative. Our legislative body decides more on what we will do, than on all possibilities that will not be feasible.

This addition will give insight in thoughts that have not reached the status of official decision making. It might show that omissions in the official standpoints have been considered.

As described in the CAP chapter 2.2 we aim at 60% reduction om CO2 emissions by 2030, leaving 40% residual emissions. Of these 40% we aim to shave of another 20 percent points by 2035, with the described actions and 'pathways' in the CCC, and with the projected national reduction of CO2-emissions. This leaves us with 20% residual emission in 2035, for which Groningen does not have a official strategy yet.
In our philosophy, this is an issue to be tackled in due time. We prioritize on emissions that we do have direct influence on, and especially on those sources that attribute most; popularly said the 20% that makes up the 80% of the problem.
These emissions that we do have influence on, already take up our full resources, meaning that we should be very careful in committing resources to mitigation policies that are less evidently effective.
The CAP is, justifiably, about relative emissions-mitigation. But one should never forget that the real problem is absolute emissions, here and now. Every ton of CO2 saved now, is worth 10 tons of CO in 2035. In practical language: we'd better concentrate on what we can do now, than on what we might be able to do in 2035.

Together with Berenschot we made an analysis of 'unavoidable' emissions, by 2030 and 2035. The term unavoidable is multi-interpretable. One could argue that emissions are avoidable, if we stop using fossil fuels and stop producing other GHG's. However, this might be economically, politically, or societally unacceptable. It is a matter of cost versus benefit, not a matter of being avoidable.

In Groningen we prefer to work with the term 'influenceable' emissions. This influence is on a multitude of levels. We made an analysis of which emissions are locally influenceable, strongly (for instance by local regulations), weakly (stimulation measures) or not (f.i. the national electricity mix).
By 2035 we expect to reduce 96% of all emissions that we do have some form of influence on. For the remaining 4% we will look into extra actions after 2030.
However, this 96% is just 40% of all emissions. On the remainder of the emissions we have no real influence on, but we expect another 40% to be reached by European and national influence. These numbers are based on the prognosis of the Dutch Bureau of Planning (2024). Some 20% (of all emissions) will remain. Theoretically, this could be compensated, but compensation is mostly out of the local scope of influence.
The JRC notes that the Berenschot calculations do not add up to 80% reductions. This is caused by the fact that some, influential, actions, such as the isolation program, have been decided on after the release of the Berenschot calculations, as explained in the previous section.
In future iterations of the CCC, we will correct for this and, of course, we will use the most accurate and up-to-date data sources.

Local compensation and carbon storage

The mission brief allows for up to 20% of the emissions to be compensated, though a reduction is preferred above compensation.
Groningen concentrates on realisation of as much reduction as possible (the 80%), before planning and committing resources to reduction of the hard-to-tackle remaining emissions or compensation of these emissions. This means that Groningen does not yet have plans for compensation, or long term capture and storage of carbon. Groningen acknowledges that these plans need to be developed in coming revisions of the Groningen CCC.

The following discussion does not represent the official standpoint of Groningen, as it has not been decided on by the municipal council, but it does illustrate our thoughts on compensation and storage.

Groningen does not possess feasible possibilities to capture or store CO2 (industrially), nor are there any feasible possibilities or plans in the surrounding region. The economic viability of industrial capturing and storing CO2 from the atmosphere is still very low, the investments needed for such a facility (on a meaningful scale) are beyond local reach.

In the city there is no industrial CO2 emitter large enough to warrant building of a large scale CCS facility. A CCS facility in the Groningen seaports (not within the administrative border of our municipality) where there are large gas, coal and bio-mass fed powerplants, could potentially be realized, but economically it is not viable yet, and there are no plans yet.

Storing CO2 in natural sinks in meaningful quantities in the Groningen area will be hard. The effectiveness of natural CO2 sinks as mitigating factor is still being debated in science. It is clear that biomass stores CO2, but it is equally clear that this storage is not forever, since a considerable fraction of this biomass will decay over time.
One of the more realistic ideas is storing CO2 in wetlands (peatforming). Groningen already has designated our wetlands (where the geophysical conditions allow) for nature, keeping them as wet as possible. This land use has been accounted for in our inventory (AFOLU emissions, Wetlands). In order to increase absorption, we would need to increase the area available for wetlands, which is difficult in the densely built-up Netherlands. Within the boundaries of Groningen, there are little to no possibilities to do so, due to geological conditions.

In the neighbouring municipalities (outside the administrative border of Groningen) new wetlands are being created (for climate resilience), as a means to keep Groningen dry in case of heavy rains. If we would look at the regional system, it is likely that nature-forming and especially the forming of new peaty wetlands, would lead to compensation.

The Groningen signees do participate in these changes of landuse, so one could reason that this could count as part of mitigating the last 20%. It has not been quantified, though, there is no data available on what this means for mitigation and compensation of emissions.
It should be noted that the Netherlands has a 4th level of democratic government, the Waterschappen (waterships). These governmental bodies intersect with the geographical areas of municipalities and even provinces. The Waterschappen have authority on quantitative and qualitative water management and play a key role in rainwater retention in wetlands and regulating waterlevels in peaty soil. In Groningen two waterships have authority over different parts of the municipal administrative area, both of them are signees of our roadmap to climate neutrality.

Groningen does have sizeable plans for regreening and planting trees and for enlarging the natural capacity of nature. One could say that GHG mitigation by regreening and nature forming is considered a co-benefit of our policies to make a green, liveable city. The policy-goals include climate resilience, healthy environment, quality of living and enlarging bio-diversity.
Since 2020, we plant 1000 trees per year, adding 30.000 sqm of greenery per year, and changing the existing greenery towards more climate resilience. We also add 1 tree per day (365 trees per year) to private gardens. On top of these policies, we have had very successful actions in giving away thousands of economically non-viable fruit-trees from professional fruit farms to inhabitants for planting them in their gardens. These are healthy trees that otherwise would have been destroyed (and would have released their stored CO2 directly).
In this CCC regreening and nature forming has not been quantified as a actions for CO2 mitigation, as there is controversy over the effects of decay overtime. In the AFOLU inventory, forest and harvested wood products are taken into account.

A possible pathway could be trading in the CO2-certificate market or investing in compensation schemes. In 2025, after the initial submission of the CCC, the EU has announced new regulations for carbon removal and carbon farming.
For now, it has been the assessment that spending public funding on carbon credits of compensation schemes is not the most effective way of using scarce resources to mitigate emissions.
It may very well be a choice when we have executed our current plans. In the next iteration of the CCC this will be taken into account.

The use of biofuels to mitigate the unavoidable emissions is a debatable solution. For real-world mitigation, we would need to produce these biofuels locally, whilst it is competing for land use with the production of food and feed. Groningen does not have enough useable area and organic waste-streams to use for replacing the remaining use of fossil fuels. Import from other regions is theoretically possible, but economically non-

viable, and it would most likely lead to relocation of emissions to regions that are not able to compete with the more affluent regions.

Groningen puts much efforts in bio-based construction, which is considered a way to store biologically sequestered carbon for longer periods. The market for biobased construction in the Netherlands is developing.
In Groningen, with our isolation program, there is a huge market opportunity for biobased insulation-materials. The supply is, alas, well below the demand. For a meaningful supply, it will take considerable changes in agricultural production, which calls for tough political calls, on national and on European level.
Together with the other Dutch mission cities, we are actively looking into market development and into changing national building regulations in favor of biobased options. The volume of biobased building in Groningen is not large enough yet, to give a meaningful quantification. We have good hopes that it will grow to a level where we can quantify it for the next iteration of the CCC.

In the CCC, scope 3 emissions are not tackled. They are not part of the Mission, though they may be the largest source of emission, world wide. Though not part of the mission, actions to tackle scope 3 missions do give insight in the efforts of cities to mitigate GHG emissions.
In our policies, we do target scope 3 emissions. Groningen is the only municipality in the Netherlands that has a vice-mayor responsible for the protein-transition: from animal proteins (and other animal products) to plant-based products. Both in our city and in the region, industry is taken this up enthusiastically, as the Groningen region is a large producer of plant-based proteins (from potatoes, sugar beets and grains).
The efforts of Groningen to reduce scope 3 emissions are labeled under the trademark 'Duurzaam Groningen' ('Sustainable Groningen'). These are efforts from our citizens and companies, following the principles of 'reduce, reuse, recycle', and supported by the municipality: repair cafés, textile and wood hubs, local consumption initiatives etc. Duurzaam Groningen also highlights these initiatives, in order to create greater popular awareness.
Groningen is has active local food policies, and is partner in European funded projects on this issue.

> We are still in the process of acquiring better data. Especially local data on scope 3 emissions are a hard nut to crack. Consumption of goods is by nature an international system that doesn't stop at local boundaries.

Action quantification and narrative

The JRC notes that Groningen has clarified that a share of emissions reduction will come from higher levels of governance. The JRC requests is to make it clear and visible that, by

summing the contribution of Groningen's actions and other actions contained in existing plans and projections, the target will be verified.

The JRC also asks about a comprehensive narrative on how systemic transformation is expected to unfold. In this section, Groningen will comment on that and hopefully reinforce impressions on the ambitions and the way we hope to reach climate neutrality.

In Chapter 5.4.1 and 5.4.2 of the Climate Action Plan, the impact of individual actions and pathways as proposed by Groningen has been quantified in terms of reduction of emissions and avoidance of emissions (Ktons CO2 eqv per year). See also table 17 and 19. The totals of these actions have been incorporated in figure 1 of the CAP (and further illustrated in the table earlier in this addition). Please note that we are not able (yet) to quantify the effects of all actions and pathways, the total impact of our actions may be larger then the totals proposed in the CAP.
In future iterations of the CCC we expect to be able to better quantify these effects, as we are increasing our organizational capacities for data acquisition and analysis.

The Groningen 'narrative' on reaching for climate neutrality is firmly based on the nature of our inhabitants: we don't talk, we act (In our regional dialect it is the proverb: 'Nait Soez'n, moar Doun!'). For the acceptance of our plans by our population, it is key that whatever we do, it proposes a realistic, but ambitious goal and timeframe. And it is key that our population sees that Groningen is making progress.

Our inhabitants understand that we, as Groningen society, are limited in the execution of our plans. If you plan to isolate a 100.000 homes, you'll need a lot of people to do so, you'll need materials, you'll need equipment, you'll need public space. Those factors are limited, so the tempo of execution is limited. And isolation is just one of the four major interventions; building a futureproof electric grid, building a heat infrastructure and climate proofing our streets are the others. There is also a fifth major intervention in public and private space: restoring and mitigating the damage done by mining-induced earthquakes.

So the narrative towards our inhabitants is: We are moving at maximum speed, you'll be able to see progress throughout the city and villages, we provide you with realistic planning of when the transition will affect your home, street or neighborhood, and we will help those that need help. If you want to go ahead, please do, we'll support you and we will help you with self-organization with similar minded people.
The narrative is also: first we'll help those who need help most, because we'll need to make sure everybody is able to participate in this transition.
To our businesses, the message is clear: we love your support, we'll help you to organize and scale-up.

The uptake of our actions is broadly supported by private citizens and by businesses and other organizations. To keep this support, we'll make sure that every inhabitant has influence on his/her surroundings by participatory processes.

Part of the no-nonsense approach is that we don't already plan actions for mitigation of remaining emissions. Before we reach for the stars, we first reach for the sky (with our boots on the ground). We don't have the capacity to execute more than we do already, so making more plans will not lead to more execution, i.e. more reduction of emissions. We will face that hurdle when it comes, armed with more knowledge, and possibly with new technologies and more favorable conditions.

Are we ambitious enough? Shouldn't we strive for more? Should we keep accelerating? In our view, you can't keep accelerating, there is a maximum speed of transition. We strive to push to that maximum speed, without falling for the trap of reaching for perfection.
By design, our plans are not complete. They need constant readjustment, we do have a obligation to monitor, evaluate and learn. We do get new insights, which we will factor in the new planning.
Groningen sees that a major push needs to be done in terms of coordination: so many parties are working on mitigation, that the real risk and problem is coordination between parties. Streamlining this coordination requires accurate data and information, which is an area we are actively working on. It also requires leadership and agreeing on governance with many parties. This is also an area which asks for continuous care from all parties involved.

Another ambition is that Groningen will share lessons learned. Regionally we provide expertise to other municipalities. Nationally we cooperate with the other Dutch mission cities on mainstreaming knowledge trough the Dutch Association of Municipalities (VNG) and the national government. And on European level, our ambition to join the Mission is a statement to our willingness to cooperate.

Appendix D: Report Energy Transition Model

Your Scenario Results

28 June, 2024 • #1156915 • by Quintel

Groningen • 2019 to 2035

At a glance...

Total energy

Initial value: **19.19 PJ** • Scenario result: **12.4 PJ**

CO_2 emissions

Initial value: **1.37 MT** • Scenario result: **928.6 TONNES**

Renewability

Initial value: **5.7%** • Scenario result: **71.5%**

Costs

Initial value: **€304 MLN** • Scenario result: **€512.55 MLN**

More information

- Your scenario has no curtailed electricity production.
- Your scenario has no blackout hours.
- In your scenario, primary energy use has been reduced to 64.6% of its value in 2019.
- Feeding in more than 10% green gas into the gas network requires large technical investments. Your scenario uses 100% green gas.
- 100% of dispatchable power plants are not profitable in your scenario. Do you think they will still be around in 2035?

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1 Introduction

This report is automatically generated by the Energy Transition Model (ETM), based on the sliders you have set in your scenario.

Each chapter in this report highlights an important result such as CO_2 emissions, cost, renewability etc. which correspond to the dashboard items of the ETM. All charts contain more information on mouse-over.

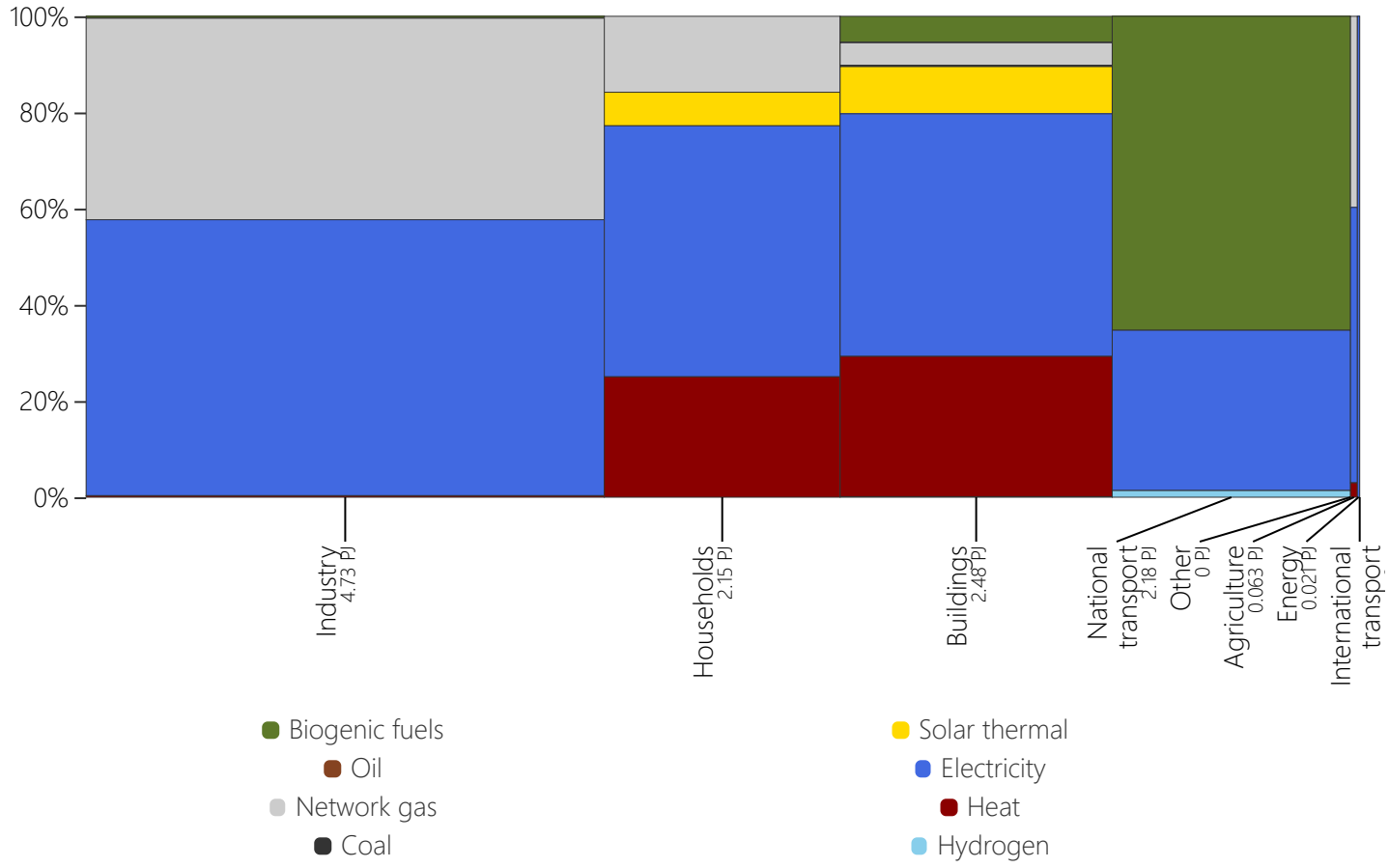
Following the dashboard-chapters, the report contains a chapter with suggestions for improving the scenario and a chapter with implications for the years leading up to the end-year.

Finally, appendix A lists all the sliders that were changed from their default value. Appendix B provides background information about the Energy Transition Model.

2 Energy use and production

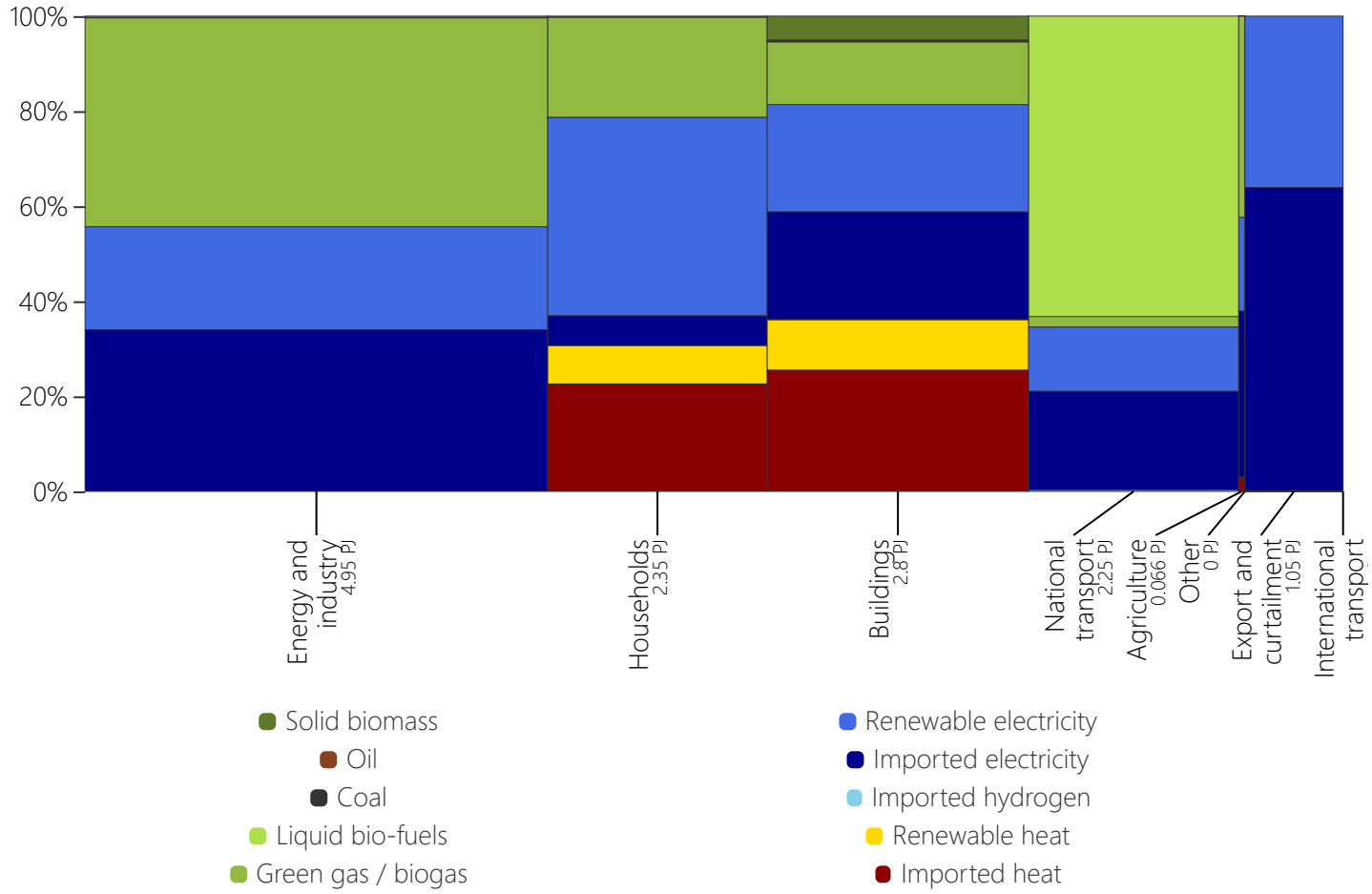
2.1 Energy consumption

The industry sector is the largest consumer of energy with 4.73 PJ of **final demand** (the energy which is directly consumed by a sector).



Final energy demand for all sectors.

When it comes to **primary demand** (final demand plus all transformation and distribution losses), the energy use for the whole system looks like this:

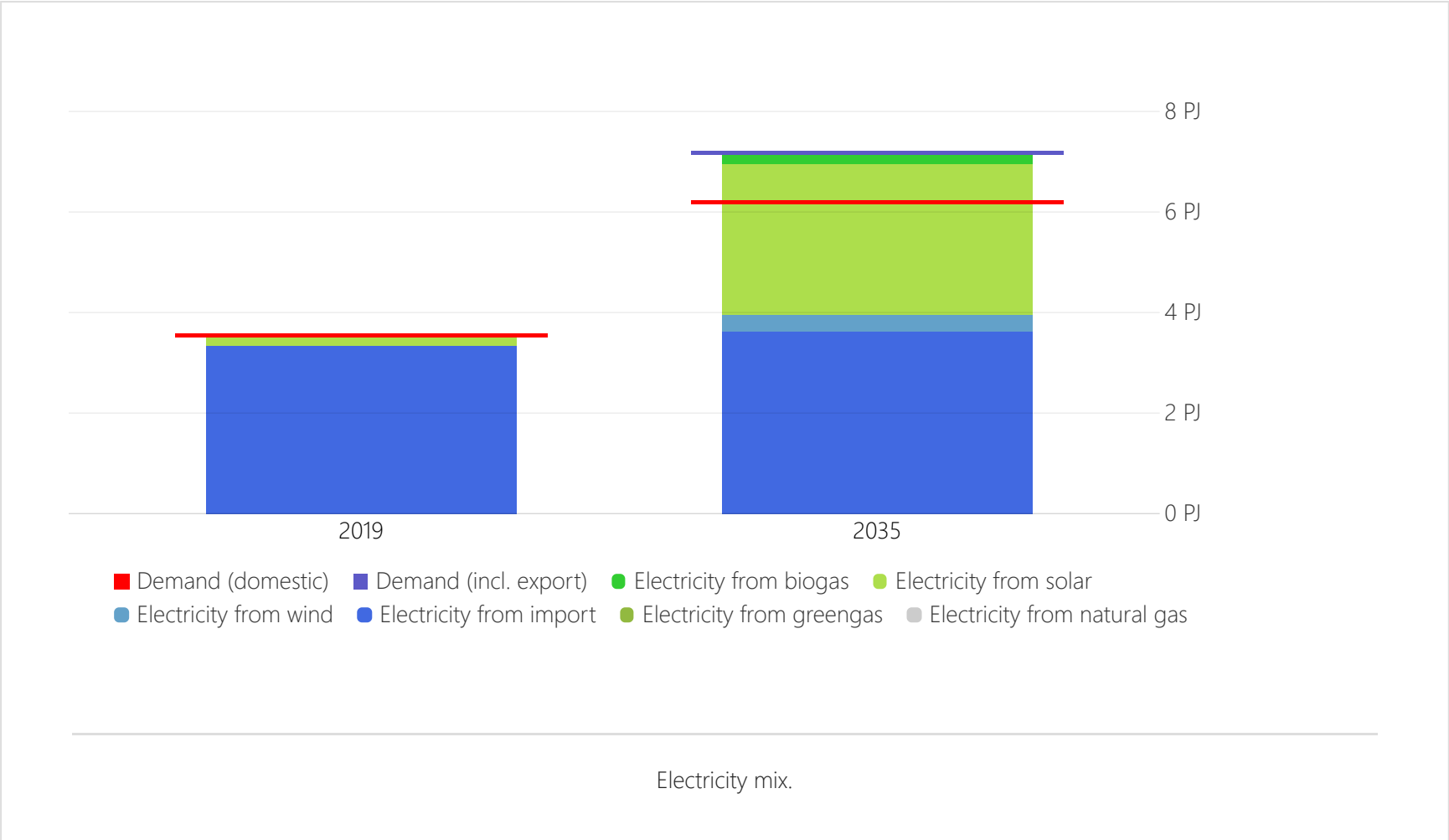

100%
80%
60%
40%
20%
0%
Energy and industry 4.95 PJ
Households 2.35 PJ
Buildings 2.8 PJ
National transport 2.25 PJ
Agriculture 0.066 PJ
Other 0 PJ
Export and curtailment 1.05 PJ
International transport
Solid biomass
Oil
Coal
Liquid bio-fuels
Green gas / biogas
Renewable electricity
Imported electricity
Imported hydrogen
Renewable heat
Imported heat

Primary energy demand for all sectors.

When looking at primary demand, exported oil (products) can play a big role if refineries are still producing at a significant rate.

2.2 **Electricity production**

In your scenario, most electricity is produced by the Solar PV plants power plant (1.71 PJ).



2.3 **District heating**

District heating in your scenario can be used to heat houses and buildings and provide heat to agricultural sectors. The chart below shows the yearly balance of heat produced and consumed.

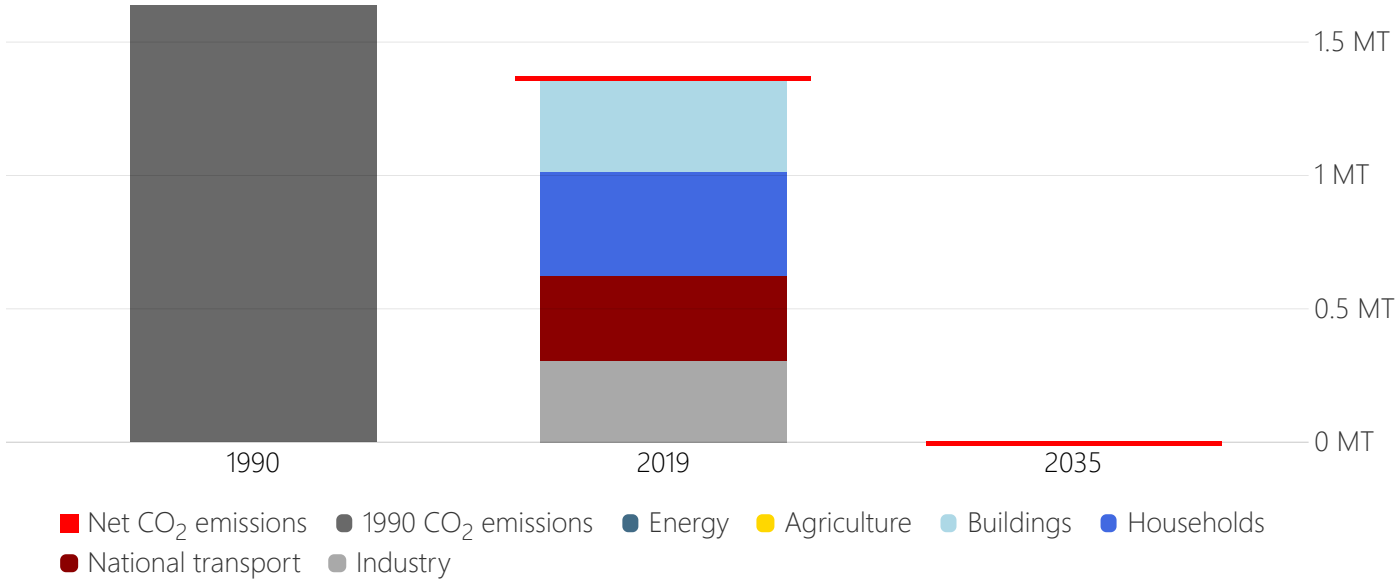
There is 0 J insufficient heat produced to satisfy the demand of the central heat network. A backup gas heater is deployed to satisfy the deficit.

You can balance the network by

- **Building more heat production**: you can generate more heat by increasing the number of heat sources
- **Decreasing demand**: by reducing the demand of all sectors in the left-hand side of the diagram

3 CO_2 emissions

In your scenario, a CO_2 emission reduction of 99.9% has been realised. The chart below relates the CO_2 in 2035 to the 1990 reference value and emissions in 2019.



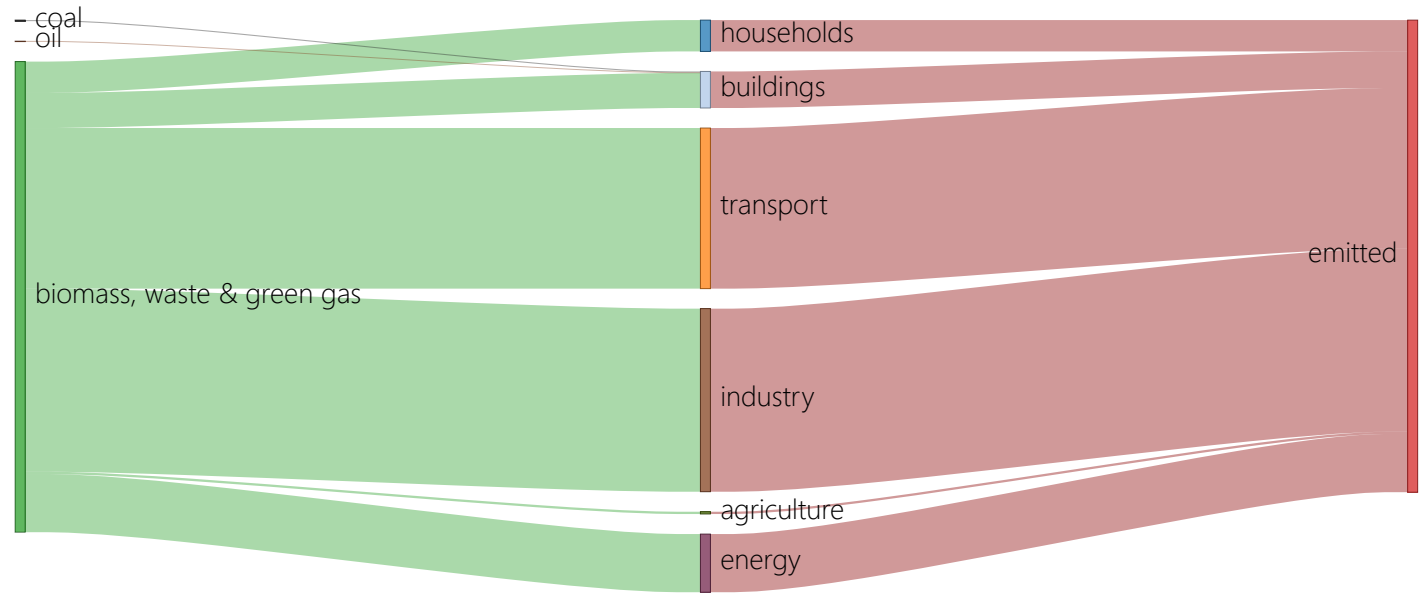
CO_2 emissions based on primary energy demand broken down by sector for 1990 (left), 2019 (middle), and 2035 (right). These figures represent emissions across the complete fuel chain including all transformations and losses.

The reduction of 99.9% exceeds the Dutch national ambition for 2030 of 49%. Your scenario even surpasses the goal of 80% - 95% reduction aimed for by the EU for 2050!

3.1 **Flow-diagram of CO_2 emissions**

The Sankey diagram below shows:

- **which** carriers are primarily responsible for CO_2 emissions (left column)
- **where** in the system CO_2 is produced (centre column)
- **which part** of the CO_2 is captured and emitted (right column)

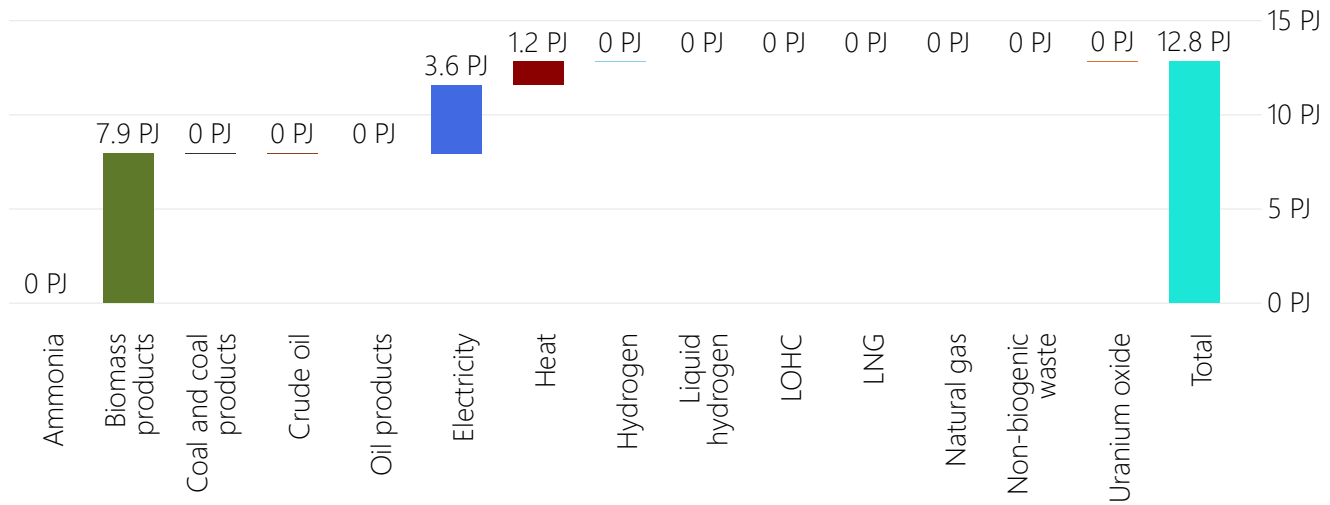


Sankey diagram showing which carriers and sectors are primarily responsible for CO_2 emissions.

You can build carbon capture and storage (CCS) power plants in the supply section of the ETM to reduce CO_2 emissions of electricity generation.

4 Energy import and export

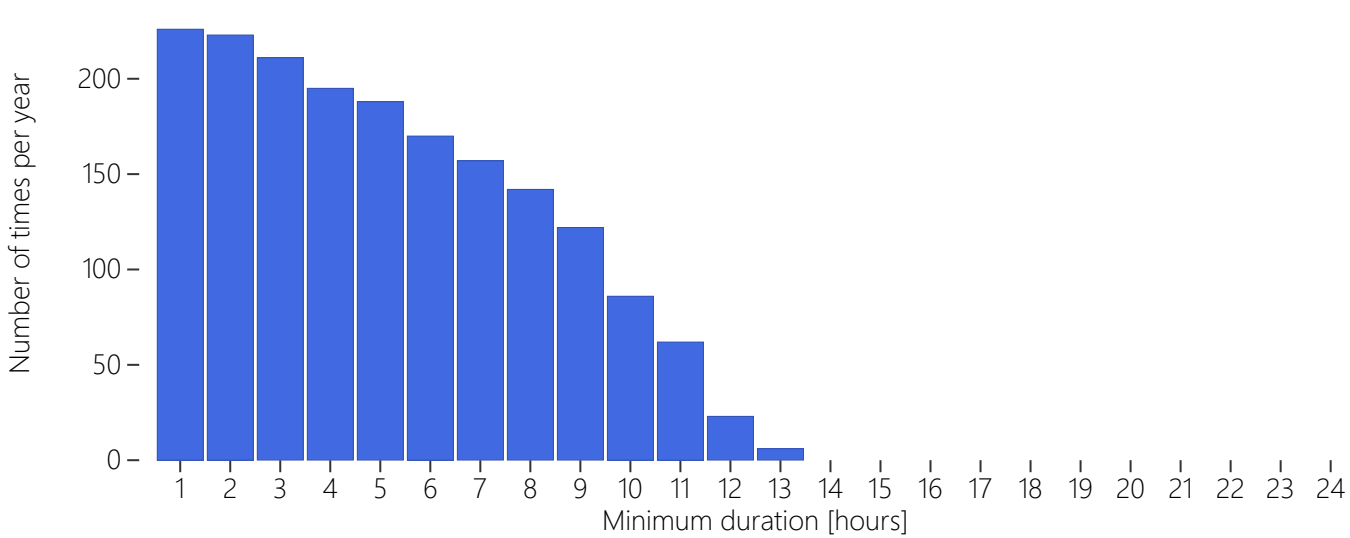
Your scenario has 11.85 PJ of net energy import in the end-year.



Import and export of energy in the end-year. In this 'waterfall' diagram, export is indicated with a minus sign. The last column depicts the net import (or export) of all energy with neighbouring countries.

4.1 Excess Electricity Production

You created a scenario where for 1811 hours in the year, (volatile and must-run) electricity production exceeds demand. The histogram below shows what the frequency and distribution of durations of excess events are.



Histogram showing number and duration of excess events.

Flexibility options such as batteries, power-to-heat and power-to-gas can be used to increase electricity demand and use it for later (storage) or for heating (power-to-heat) or replace natural gas (power-to-gas). In section Unused potential, more details of how to use excess can be found.

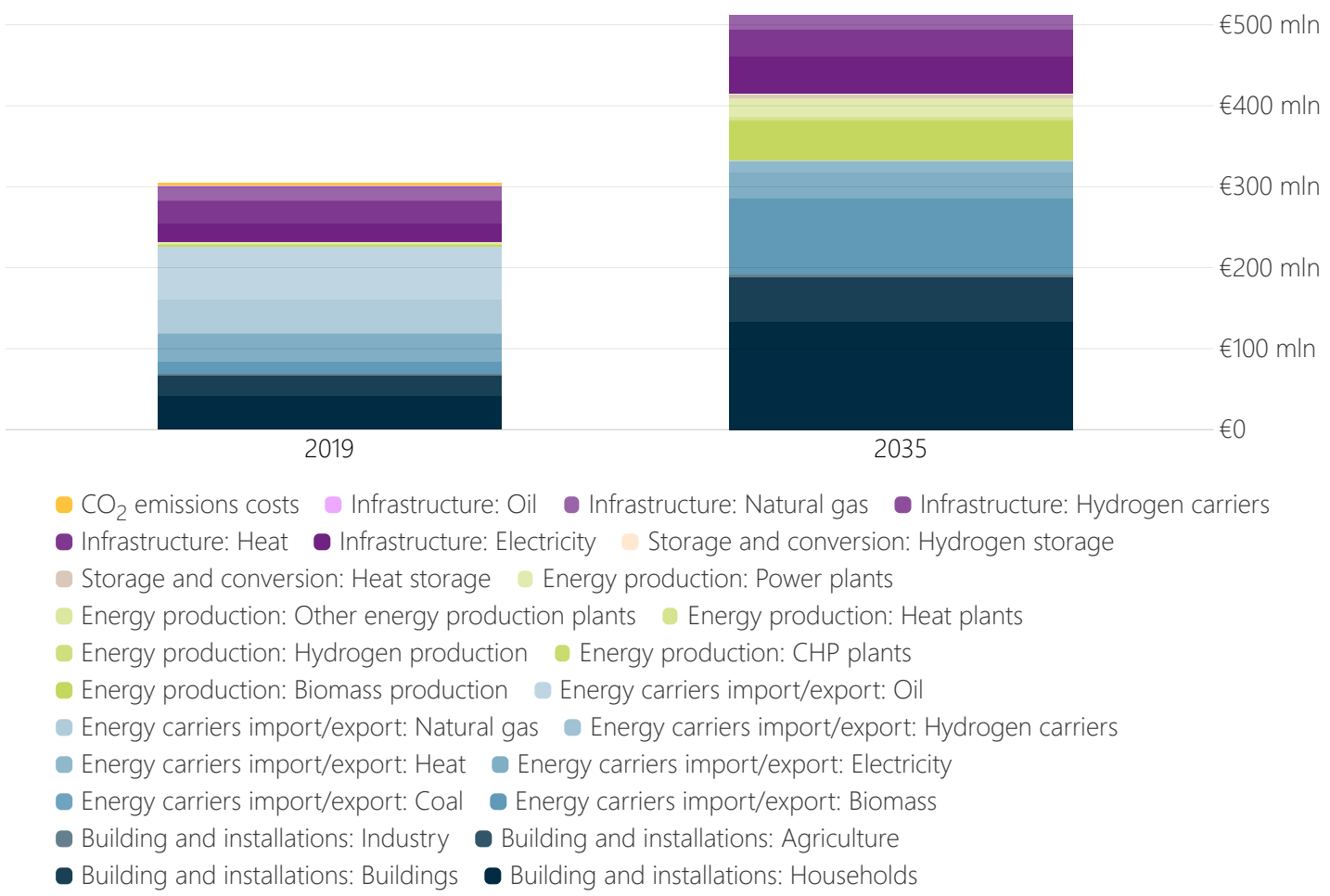
5 Costs of the energy system

5.1 Cost of the energy system

Costs of the future energy system are roughly €0.51 and are broken down in the following chart. Costs include

- **Investments**.
- **Fuel costs**: using fuel prices set in the costs section.
- **Operation and Maintenance**: both variable and fixed.
- **Weighted average costs of capital**: assuming linear depreciation.
- **Decommissioning costs**: relevant for nuclear power plants only.

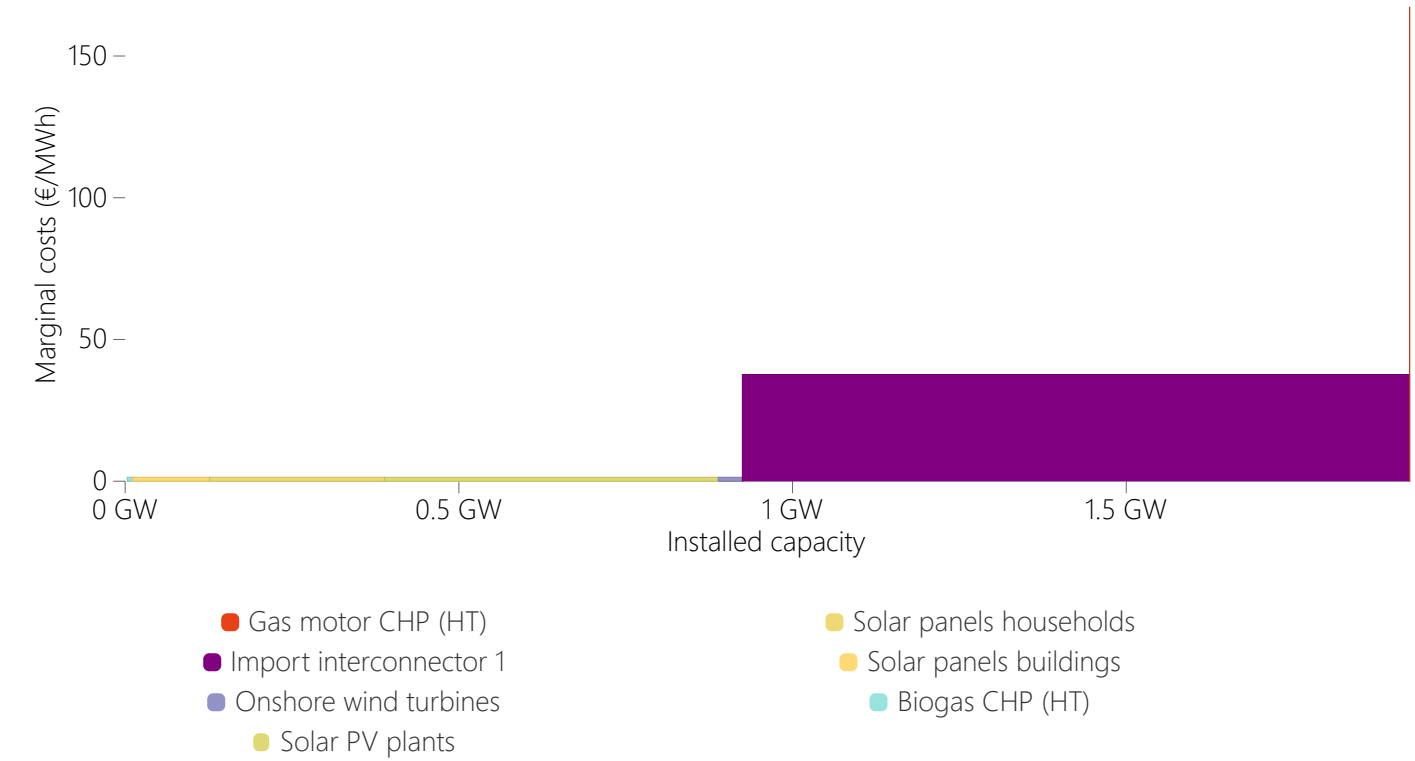
Costs do **not** include subsidies and taxes.


€500 mln
€400 mln
€300 mln
€200 mln
€100 mln
€0
2019
2035
CO_2 emissions costs
Infrastructure: Oil
Infrastructure: Natural gas
Infrastructure: Hydrogen carriers
Infrastructure: Heat
Infrastructure: Electricity
Storage and conversion: Hydrogen storage
Storage and conversion: Heat storage
Energy production: Power plants
Energy production: Other energy production plants
Energy production: Heat plants
Energy production: Hydrogen production
Energy production: CHP plants
Energy production: Biomass production
Energy carriers import/export: Oil
Energy carriers import/export: Natural gas
Energy carriers import/export: Hydrogen carriers
Energy carriers import/export: Heat
Energy carriers import/export: Electricity
Energy carriers import/export: Coal
Energy carriers import/export: Biomass
Building and installations: Industry
Building and installations: Agriculture
Building and installations: Buildings
Building and installations: Households

Costs of the energy system.

5.2 **Merit order and fuel prices**

The *merit order* ranks dispatchable power plants (those which you can switch on and off) according to their *marginal costs* (the costs of producing an extra MWh of electricity). Wind, solar and must-run plants have effectively zero marginal costs. The marginal costs and installed capacity of power generation for your scenario is shown in the chart below.



Merit order.

Depending on the demand for electricity, the merit order determines which plants are running for each hour of the year. The plants with lowest marginal costs will often (baseload generation) whereas plants with higher marginal costs might

only run in cases of peak demand.

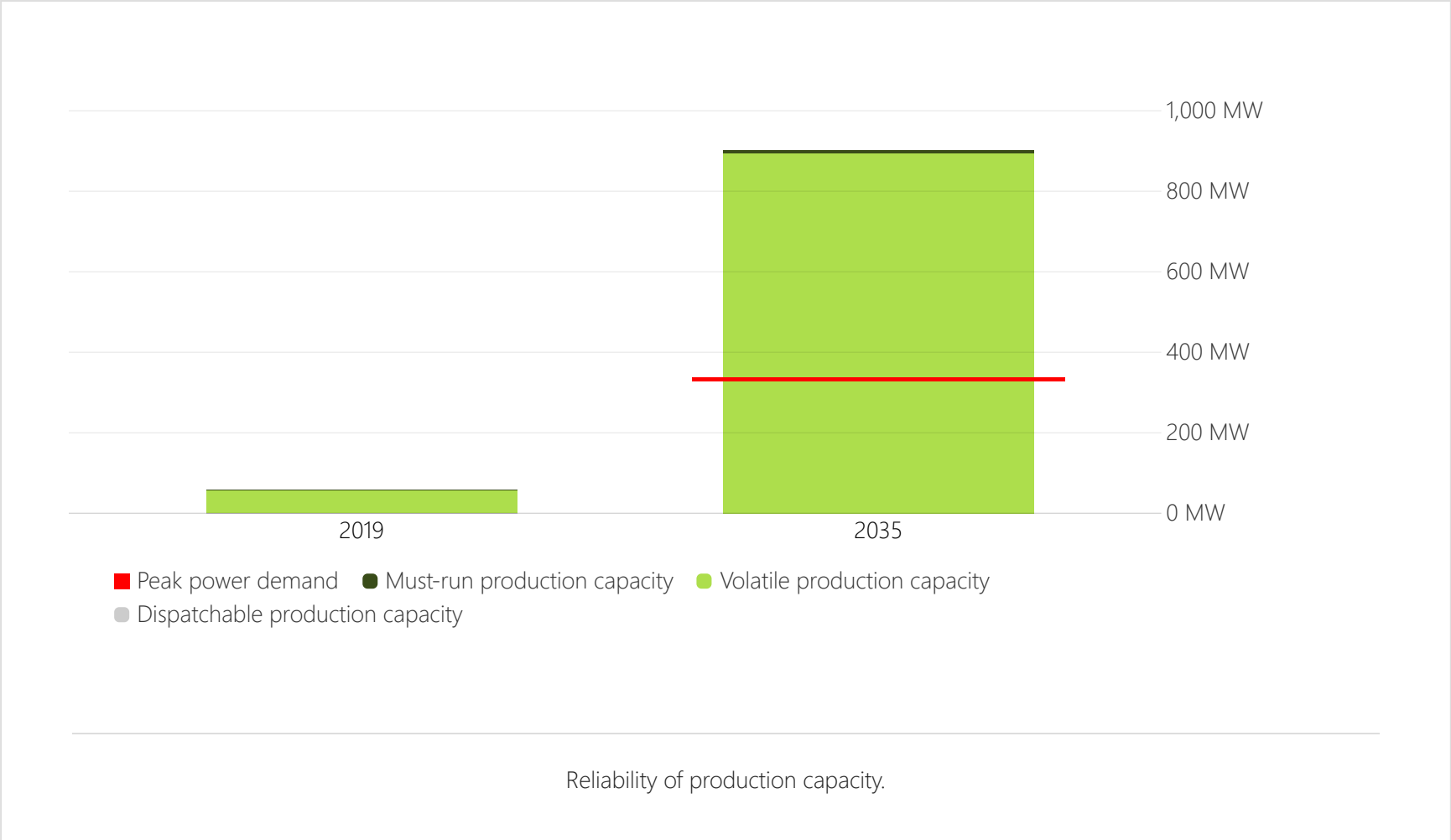
Fuel prices determine to a large extend the marginal costs of power plants. Increasing the price of coal and/or CO_2 can, for instance, make gas fuelled power plants more competitive with coal fired power plants.

6 Security of supply and profitability of dispatchable power plants

6.1 Reliability

The loss of load expectation (LOLE) is the expected number of hours per year that the electricity supply cannot meet its demand. A nonzero LOLE does not necessarily result in blackouts as electricity can be imported or can be available in batteries. The Netherlands accepts a LOLE of 4 h/yr. We distinguish (un)reliable electricity production as volatile electricity producers cannot be relied on at all times.

In your scenario, there is 12.17 KW of reliable (dispatchable) electricity production. Resulting in 7014 hours of loss of load.



Similar to LOLE, the number of blackout hours is a measure for the reliability of the electricity supply in your scenario. It also takes into account the possibility for import and flexibility to prevent a shortage of power.

Your scenario has zero blackout hours.

6.2 **Profitability of dispatchable power plants**

Security of (electricity) supply and the profitability of dispatchable power plants are intimately linked. For dispatchable power plants to make money, they need to run sufficiently often, ideally when electricity prices are high. A reliable electricity system traditionally requires, however, that there are power plants available which are only needed for a couple of extreme demand peaks every year.

In your scenario, 100% of the dispatchalbe power plants is not profitable. This means that they are not earning back their investment costs (orange in table below) or are not even earning their OPEX (operational expenditure) back (red).

Technology	Merit order position	Installed capacity	Availability	Full load hours, future	Average profit per MWh
Gas motor CHP (HT)	1	12.81 kW	95%	0	€0

Profitable **Covers operating costs** **Unprofitable**

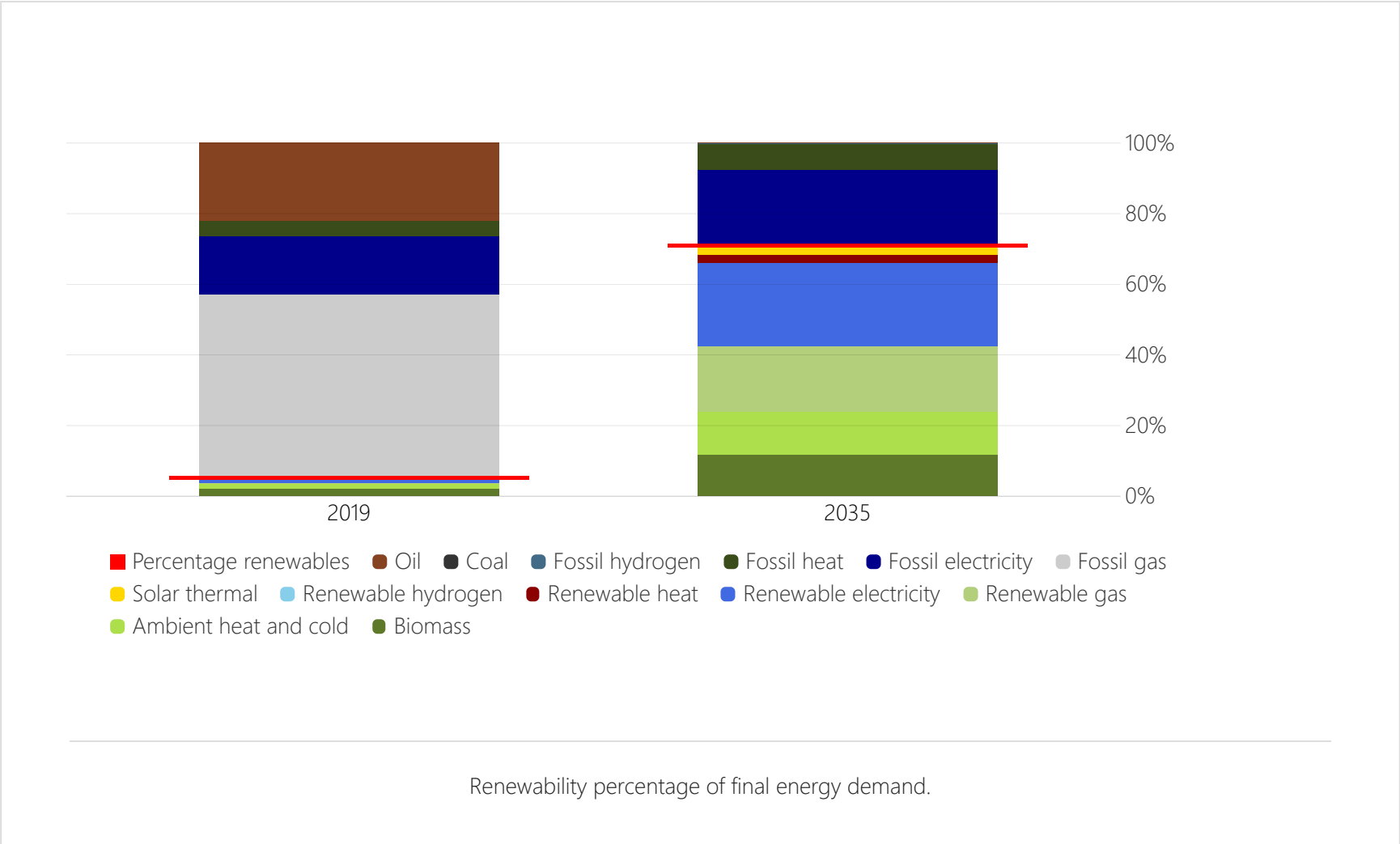
Profitability of dispatchable power plants.

Unprofitable plants will likely be taken out of commission after a while. You can improve their profitability by increasing electricity demand (making them run more hours). Also reducing electricity generation with zero marginal costs can make power plants profitable again.

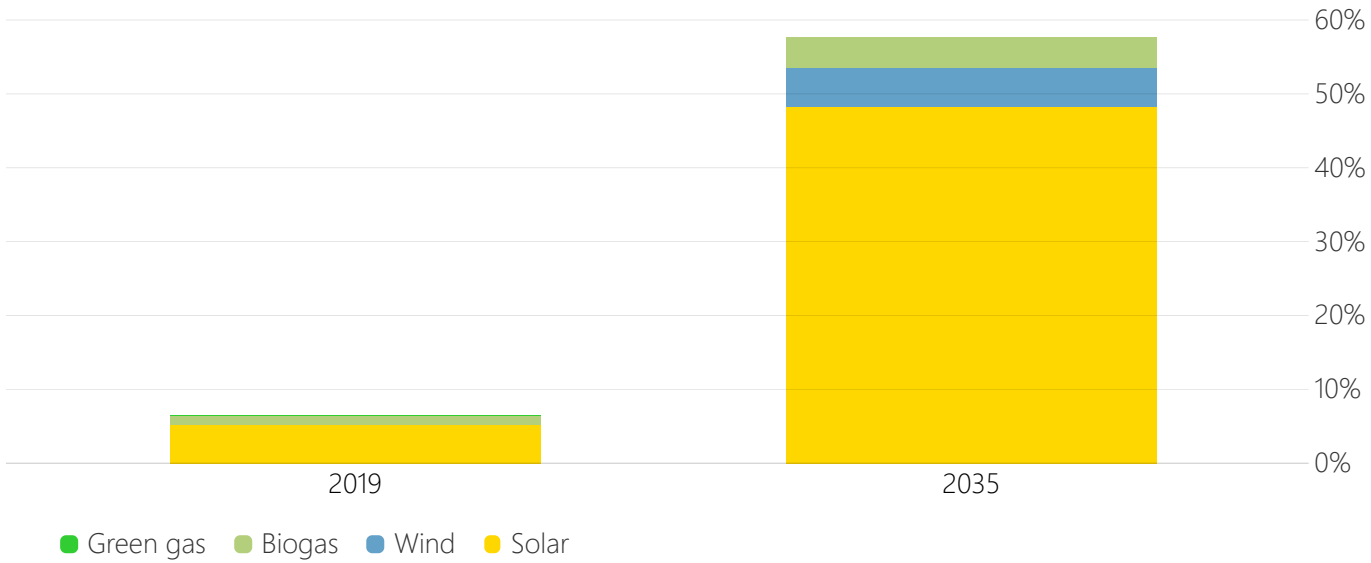
7 Renewability

7.1 Renewability

The percentage of renewable energy in your scenario is 71.5%.



For electricity generation, the renewability is 57.7%.



Renewability of produced electricity. The renewability is defined as all renewable electricity production divided by local electricity consumption and can be larger than 100%.

8 Implications of this scenario

8.1 Investments needed

Your scenario spans 16 years. The various assumptions imply that on average the following list of technologies need to be installed every year

- 0 off-shore wind turbines
- 0.7 inland wind turbines
- 0 coastal wind turbines
- 4821.9 electric vehicles

8.2 Area needed for wind

- Coastal area used by wind: 0 km^2
- Area used by off-shore wind: 0 km^2
- Area used by inland wind: 2.4 km^2

9 Suggestions for improvement

9.1 Possible inconsistencies

9.1.1 Refineries and electric vehicles

In your scenario, electric vehicles constitute 85% of all cars, yet oil refineries are still 100% of their current size. Do you think this is realistic? For an analysis of the correllation between electrification of transport and the size of the refinery sector see the report "Industry in Transition" (Quintel Intelligence 2016).

Sankey diagram of oil products in refineries.

9.1.2 Size of steel industry and electric vehicles

Like oil refineries, a large part of the production output of steel plants is currently dedicated to cars. If, self-driving electric vehicles start to replace fossil fuel cars, the number of cars can be reduced dramatically. In your scenario, electric vehicles constitute 85% of all cars, yet the steel industry is still 100% of its current size. Do you think this is realistic?.

9.2 Extreme assumptions

Depending on your choices, this section highlights some assumptions which imply big changes in the energy system. This might help you to focus on which aspects of your scenario could use some extra argumentation or research.

9.2.1 Green gas and areable land

Your scenario has 100% of greengas mixed into the gas network.

In your scenario, 100% of power plants is not profitable. This means that they are not earning back their investment costs and sometimes not even their running costs. Such plants will not stay open very long. Having them around in your future year might not be realistic. You can either

- **Increase electricity demand**: making the unprofitable plants run more hours could improve their situation.
- **Reduce competing production**: typically, wind and solar electricity generation has marginal costs close to zero, 'pushing' conventional plants out of the merit order.
- **Close the plants**: closing unprofitable plants might increase the realism of your scenario as such plants are not expected to exist very long.

10 Appendix A: Slider settings

This appendix lists all the sliders which have been moved from their default value.

Demand • Passenger transport • Applications

- Passenger transport: 0% → 0.49%
- Cars: 67.76% → 52.63%
- Trains: 8.01% → 15%
- Buses: 13% → 10.16%
- Motorcycles: 3% → 5%
- Bicycles: 7.73% → 17.21%

Demand • Passenger transport • Car technology

- Electric: 1.93% → 85%
- Hydrogen: 0.01% → 0%
- Diesel: 18.31% → 3%
- Gasoline: 78.37% → 12%
- LPG: 1.38% → 0%

Demand • Passenger transport • Train technology

- Electric: 81.99% → 89%
- Hydrogen: 0% → 11%
- Diesel: 18.01% → 0%

Demand • Passenger transport • Bus technology

- Electric: 40.28% → 100%

- Hydrogen: 0.41% → 0%
- Diesel: 59.06% → 0%
- Compressed gas: 0.25% → 0%

Demand • Passenger transport • Motorcycle technology

- Gasoline: 81.73% → 50%
- Electric: 18.27% → 50%

Demand • Passenger transport • Bicycle technology

- Bike: 84% → 20%
- E-bike: 16% → 80%

Demand • Households • Population & housing stock

- Population: 231.3 K → 250 K
- New residences: 0 → 15,971.18
- 2005 - present: 716 → 465.27
- 1985 - 2004: 1,656 → 1,076.1
- 1965 - 1984: 817 → 530.9
- 1945 - 1964: 680 → 441.88
- < 1945: 2,271 → 1,475.74
- 2005 - present: 1,815 → 1,695.38

- 1985 - 2004: 3,849 → 3,595.34
- 1965 - 1984: 4,848 → 4,528.5
- 1945 - 1964: 1,538 → 1,436.64
- < 1945: 2,789 → 2,605.19
- New residences: 0 → 5,404.22

Demand • Households • Heat demand & insulation

- New residences: 65 → 47
- 2005 - present: 121.42 → 47
- 1985 - 2004: 155.43 → 47
- 1965 - 1984: 191 → 47
- 1945 - 1964: 218.02 → 47
- < 1945: 223.51 → 47
- New residences: 55 → 47
- 2005 - present: 115.87 → 47
- 1985 - 2004: 141.79 → 47
- 1965 - 1984: 209.23 → 47
- 1945 - 1964: 264.29 → 47
- < 1945: 296.23 → 47
- New residences: 55 → 47

- 2005 - present: 115.96 → 47
- 1985 - 2004: 148.25 → 47
- 1965 - 1984: 196 → 47
- 1945 - 1964: 253.26 → 47
- < 1945: 276.33 → 47
- New residences: 55 → 47
- 2005 - present: 113.51 → 47
- 1985 - 2004: 151.36 → 47
- 1965 - 1984: 183 → 47
- 1945 - 1964: 223.98 → 47
- < 1945: 251 → 47

Demand • Households • Space heating & hot water

- Solar thermal collectors: 0% → 19.71%
- Condensing combi boiler (gas): 75.35% → 0%
- HT district heating: 16.14% → 35%
- Air heat pump: 1.69% → 10%
- Ground heat pump: 0.56% → 5%
- Hybrid air heat pump (gas): 0.12% → 50%
- Biomass boiler: 2.85% → 0%

- Electric boiler: 1.01% → 0%
- Gas-fired heater: 2.28% → 0%

Demand • Households • Cooling

- Ground heat pump: 8.67% → 5%
- Air heat pump: 26% → 60%
- Airconditioning: 65.23% → 35%

Demand • Households • Cooking

- Gas: 60.97% → 0%
- Electric: 3.06% → 0%
- Halogen: 24.51% → 0%
- Induction: 9.19% → 100%
- Biomass: 2.26% → 0%

Demand • Households • Appliances

- Dish washer: 0% → 28%
- Fridge / Freezer: 0% → 28%
- Washing machine: 0% → 28%
- Dryer: 0% → 28%
- Television: 0% → 28%

- Computer / Media: 0% → 15%
- Vacuum cleaner: 0% → 28%
- Other: 0% → 28%

Demand • Households • Lighting

- Incandescent: 40.93% → 0%
- Low-energy light bulb: 48% → 10%
- LED: 10.57% → 90%

Demand • Households • Development of demand

- Electric appliances: 0% → 2%

Demand • Households • Behaviour

- Turn off appliances: 0% → 75%
- Turn off the light: 0% → 75%
- Low-temperature washing: 0% → 45%

Demand • Freight transport • Applications

- Freight transport: 0% → 0.49%
- Trucks: 77.12% → 55.44%
- Trains: 3.88% → 9.99%
- Vans: 0% → 0.28%

- Domestic navigation: 19% → 34.29%

Demand • Freight transport • Truck technology

- Electric: 0% → 10%
- Diesel: 100% → 90%

Demand • Freight transport • Van technology

- Electric: 3.06% → 10%
- Hydrogen: 0.07% → 0%
- Diesel: 87.88% → 90%
- Gasoline: 5.58% → 0%
- LPG: 3.41% → 0%

Demand • Freight transport • Train technology

- Electric: 86.66% → 80%
- Hydrogen: 0% → 20%
- Diesel: 13.34% → 0%

Demand • Freight transport • Domestic navigation technology

- Diesel (single / dual / multi-fuel engine): 100% → 50%
- LNG: 0% → 50%

Demand • Buildings • Building stock

- New buildings: 0 → 2,407.94

Demand • Buildings • Heat demand & insulation

- New buildings: 190 → 173.19
- Present buildings: 247.15 → 225.28

Demand • Buildings • Space heating

- Solar thermal collectors: 0% → 76.92%
- Condensing combi boiler (gas): 86.99% → 5.56%
- Condensing combi boiler (hydrogen): 0% → 0.14%
- HT district heating: 5.13% → 33.33%
- Air heat pump: 0% → 0.14%
- Ground heat pump with TS: 7.69% → 55.56%
- Biomass-fired heater: 0.19% → 5%
- Oil-fired heater: 0% → 0.14%
- Coal-fired heater: 0% → 0.14%

Demand • Buildings • Cooling

- Ground heat pump with TS: 9.36% → 55.56%
- Airconditioning: 90.64% → 44.44%

Demand • Buildings • Appliances

- Appliances efficiency: 0% → 2.25%

Demand • Buildings • Lighting

- Fluorescent tube: 90.02% → 0%
- High-performance fluorescent tube: 1.52% → 5%
- LED-tube: 8.46% → 95%
- Motion detection: 26.52% → 95%
- Daylight-dependent control: 20.51% → 95%

Demand • Buildings • Development of demand

- Cooling per building: 0% → -1.03%

Demand • Industry • Chemicals

- Size: 100% → 111%
- Electricity: 0% → 15.56%
- Heat: 0% → 15.56%
- Gas-fired heater: 100% → 0%
- Biomass-fired heater: 0% → 25%
- Electric boiler: 0% → 50%
- Steam network: 0% → 25%
- Network gas: 0% → 3.78%

- Oil: 100% → 96.22%

Demand • Industry • Central ICT

- Size: 100% → 310.81%
- Efficiency improvement: 0% → 15.56%

Demand • Industry • Food

- Size: 100% → 128%
- Electricity: 0% → 15.56%
- Heat: 0% → 15.56%
- Gas-fired heater: 100% → 50%
- Electric boiler: 0% → 50%

Demand • Industry • Paper

- Size: 100% → 111%
- Electricity: 0% → 15.56%
- Heat: 0% → 15.56%
- Gas-fired heater: 100% → 50%
- Electric boiler: 0% → 50%

Demand • Industry • Other

- Size (energetic): 100% → 90%

- Size (non-energetic): 100% → 90%
- Electricity: 41.77% → 50%
- Gas: 58.23% → 50%

Demand • Industry • Steam network sources

- Geothermal heat: 0 W → 490.51 KW

Demand • Agriculture • Development of demand

- Electricity: 0% → 2%
- Heat: 0% → -1%

Demand • Agriculture • Heat

- Gas-fired heater: 99% → 75.19%
- Water heat pump with TS: 0% → 18.51%
- HT district heating: 1% → 6%

Demand • Agriculture • Heat from local CHPs

- Gas motor CHP: 11.85 KW → 0 W
- Biogas CHP: 31.57 KW → 0 W

Supply • HT district heating • Sources

- Solar thermal: 0 W → 37 MW

- Residual heat: 0 J → 112.39 TJ
- Imported heat: 0 J → 1.24 PJ
- Collective heat pump: 3.8 MW → 15 MW

Supply • Electricity • Gas plants

- Gas motor CHP: 9.82 KW → 12.81 KW

Supply • HT district heating • (Seasonal) storage of heat

- : 0 → 1

Supply • Renewable electricity • Wind turbines

- Onshore inland: 134.24 KW → 36 MW

Supply • Renewable electricity • Solar power

- Solar PV households: 27.99 MW → 261.96 MW
- Solar PV buildings: 14.27 MW → 115.39 MW
- Solar PV plants onshore: 16.69 MW → 500 MW

Supply • Renewable electricity • Biomass plants

- Biogas CHP: 1.48 MW → 8.32 MW

Supply • Hydrogen • Hydrogen production

- Solar PV plant for H_2: 0 W → 3.95 MW

- H_2 import: 0 W → 96.95 KW

Supply • Hydrogen • Hydrogen storage

- Storage volume: 0 WH → 2.16 GWH
- Relative storage capacity: 250 [MISSING → 500 [MISSING

Supply • Transport fuels • Road transport

- Diesel: 93.89% → 0%
- Biodiesel: 6.11% → 100%
- Gasoline: 94.09% → 0%
- Bio-ethanol: 5.91% → 100%
- LNG: 100% → 0%
- Bio-LNG: 0% → 100%

Supply • Transport fuels • Rail transport

- Diesel: 100% → 0%
- Biodiesel: 0% → 100%

Supply • Transport fuels • Domestic navigation

- Diesel: 100% → 0%
- Biodiesel: 0% → 50%
- Bio-LNG: 0% → 50%

- LNG: 100% → 0%
- Bio-LNG: 0% → 100%

Supply • Biomass • Gas mix in gas network

- Natural gas: 99% → 0%
- Green gas: 1% → 100%

Supply • Biomass • Wood pellets in steel production

- Wood pellets in cyclone furnace: 0% → 5%

Supply • Biomass • Biocoal and bio-oil in energy plants

- Coal: 100% → 0%
- Biocoal: 0% → 100%

Flexibility • Electricity storage • Batteries in households

- Willingness to pay: 4 → 1
- Willingness to accept: 4.44 → 2

Flexibility • Electricity storage • Batteries in electric vehicles

- Deployable capacity: 0% → 25%
- Willingness to pay: 4 → 1
- Willingness to accept: 4.71 → 2

Flexibility • Electricity storage • Large-scale batteries

- Willingness to pay: 4 → 1
- Willingness to accept: 4.94 → 2

Flexibility • Electricity storage • Reservoirs

- Willingness to pay: 4 → 1
- Willingness to accept: 6 → 2

Flexibility • Electricity storage • Underground pumped hydro storage

- Willingness to pay: 4 → 1
- Willingness to accept: 5.37 → 2

Flexibility • Electricity conversion • Conversion to hydrogen

- Power-to-gas: 30 → 0

Flexibility • Electricity conversion • Conversion to heat for district heating

- Power-to-heat boiler: 19 → 0
- Power-to-heat heat pump: 20 → 0

Flexibility • Electricity conversion • Conversion to heat for industry

- Power-to-heat boiler for refineries: 22 → 0
- Power-to-heat boiler for chemical industry: 22 → 0

- Power-to-heat boiler for food industry: 22 → 0
- Power-to-heat boiler for paper industry: 22 → 0

Flexibility • Net load • Demand response - behavior of hybrid heat pumps

- Space heating (gas): 2.6 → 1

Flexibility • Weather conditions • Extreme weather conditions

- Outdoor temperature: 0 → 1
- Onshore inland: 2,069.33 → 2,600
- Solar PV: 867 → 950

Flexibility • Import/Export • Interconnector 1

- Interconnector capacity: 60 GW → 1 GW
- Present import: 370 → 490
- Future import: 370 → 0

Emissions • Emission factors • CO_2 emissions of imported heat

- CO_2 emissions of imported heat: 35.97 → 0

Emissions • Emission factors • CO_2 emissions of imported hydrogen carriers and ammmonia

- Hydrogen: 280.8 KG/MWH → 0 KG/MWH

Costs & efficiencies • Electricity • Coal plants

- Investment costs coal plant: 0% → -2%
- O&M costs coal plant: 0% → -2%

Costs & efficiencies • Electricity • Gas plants

- Investment costs gas plants: 0% → -2%
- O&M costs gas plant: 0% → -2%

Costs & efficiencies • Electricity • Oil plants

- Investment costs oil plants: 0% → -2%
- O&M costs oil plants: 0% → -2%

Costs & efficiencies • Electricity • Nuclear plants

- Investment costs large reactors: 0% → -22.13%
- O&M costs large reactors: 0% → 72.92%

Costs & efficiencies • Renewable electricity • Wind turbines

- Investment costs onshore: 0% → -10%
- O&M costs onshore: 0% → -15%
- Investment costs offshore: 0% → -40%
- O&M costs offshore: 0% → -40%

Costs & efficiencies • Renewable electricity • Solar power

- Investment costs solar panels: 0% → -60%

Costs & efficiencies • Renewable electricity • Biomass plants

- Investment costs biomass plant: 0% → -2%
- O&M costs biomass plant: 0% → -2%

Costs & efficiencies • Renewable electricity • Waste power

- Investment costs waste incinerator: 0% → -2%
- O&M costs waste incinerator: 0% → -2%

Costs & efficiencies • Heat • Costs heating

- Electric heat pumps: 0% → -35%
- Households LT heat delivery system: 0% → -35%
- Investment costs geothermal energy: 0% → -20%

Costs & efficiencies • Transport • Efficiencies

- Electric vehicles: 0% → 2%
- Hydrogen vehicles: 0% → 2.55%
- Combustion engine vehicles: 0% → 1%

Costs & efficiencies • Fuel prices • Fossil fuels

- Natural gas: 14 → 29.88

- Oil: 64.15 → 108
- Coal: 65.94 → 67.75

Costs & efficiencies • CCUS • Prices

- Captured biogenic CO_2 price: 24.83 → 0

11 Appendix B: About The Energy Transition Model

11.1 Introduction

The Energy Transition Model (ETM) is a free, open-source, web-based energy model for the exploration of energy scenario's.

The ETM is for anyone who wants to explore and create energy scenarios for countries, cities, neighbourhoods and even streets. No prior knowledge is assumed and the ETM is therefore of interest to both experts and students. You can make assumptions about demand and supply of different types of energy from the source to the application. the ETM determines, for all stakeholders in the system, sustainability, reliability and affordability at national and local level.

You can look up how the ETM compares to other models on energierekenmodellen.nl.

11.2 Beyond The Energy Transition Model

> All models are wrong but some are useful.
> *~ George Box*

Although Quintel strives to properly include all important features of the energy system, the ETM necessarily has a limited scope and should not be used as a substitute for critical thought. On the contrary! Hopefully, the user is inspired to

challenge results and limits of the model and starts thinking outside of the boundaries of the Energy Transition Model.

The following (very) incomplete list of topics is indicative of the limits of the ETM:

- **Human behaviour**: arguably the biggest impact on the success of failure of energy transition is declared out of scope of the primarily technical ETM.
- **Economic relations**: the ETM calculates costs based on published values but does not assume price-elasticity relations or other economic relations which may no longer apply in the future.
- **Policy**: no subsidies or taxes are assumed in the ETM, they are viewed as the possible motivation for the choices of the user, however.