Frisian greenhouse gas emission policy

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LIST OF ABBREVIATIONS

BAU	-	Business-as-usual
CCS	-	Carbon Capture and Storage
FMF	-	Frisian Environmental Federation (Dutch: Friese Milieufederatie)
GHG	-	Greenhouse gas
IPCC	-	Intergovernmental Panel on Climate Change
LNF	-	Land use, Nature and Forestry
LTO	-	Agricultural Organization (Dutch: Land- en Tuinbouw Organisatie)
LULUCF	-	Land Use, Land Use Change and Forestry

SUMMARY

This study researched the greenhouse gas (GHG) emission policy for the rural province of Friesland. The transition towards lower GHG emissions will have a large impact on the landscape. The regional governmental level of provinces is responsible for spatial planning; therefore, provinces are important for GHG emission-reducing policy. It is evaluated whether the current policies in Friesland are enough to reach the Paris agreement target of 95% emission reduction.

Current policy planned by Friesland focusses on energy-related GHG emissions. Friesland aims to be fossil fuel free 2050. Policy for GHG emissions from biogenic sources (produced by living organisms) is minimally discussed in the policy documents. A data-analysis of current GHG emissions of Friesland shows that most emissions are attributed to the biogenic sectors: agriculture and landuse, nature & forestry. While nationally only 17% of the GHG emissions are attributed to these sectors, Friesland has 60% of its GHG emissions attributed to these sectors.

The GHG emission policy and the GHG emissions are further analyzed in a quantitative scenario analysis in the regional emission model (REM). GHG emissions are calculated for three scenarios: BAU, PLUS and PARIS. Both current policy (BAU) and doubled targets for emission reduction (PLUS) are not enough to reduce emissions by the Paris agreement target. The third scenario includes drastic measures to reduce GHG emissions by 95%. A sociopolitical assessment is conducted by interviewing five stakeholders representing the major parties in Friesland. Willingness of discussed biogenic GHG emission reducing policies were lower than energy-related GHG emissions policies. Compensation for loss of income and public opinion of technologies came forward as major conflicting interests.

Policies and targets show promise to the ability of Friesland to eliminate energy-related GHG emissions by 2050. However, major challenges are found in reducing biogenic GHG emissions.

SAMENVATTING

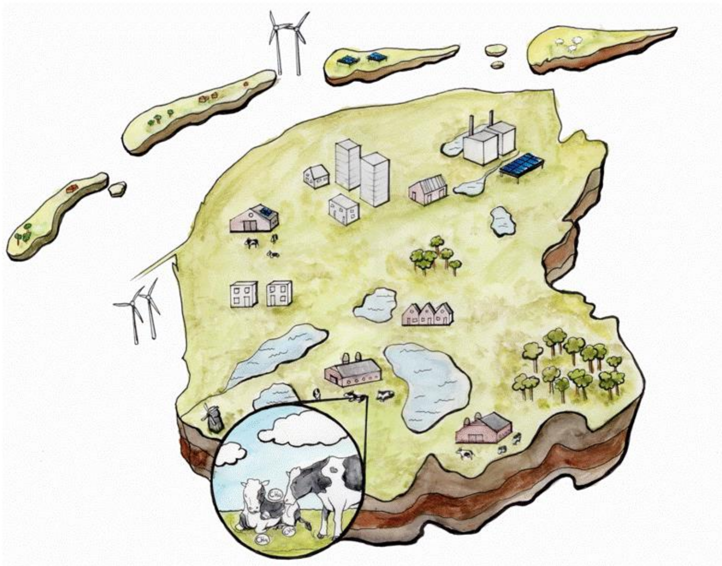
Deze studie onderzoek het broeikasgas (GHG) emissiebeleid voor Friesland; een provincie met een landelijk karakter. De transitie naar lagere GHG-emissies zal een grote impact hebben op het landschap. Provincies zijn verantwoordelijk voor ruimtelijke ordening. Daardoor zijn provincies belangrijk voor het GHG-emissiereductie beleid. Deze studie is uitgevoerd vanuit de vraag of het huidige beleid toereikend is om het doel in het akkoord van Parijs van 95% emissiereductie te halen.

Het huidige beleid van Friesland richt zich op energie-gerelateerde GHG-emissies. Belangrijk is het doel om in 2050 100% onafhankelijk te zijn van fossiele brandstoffen in Friesland. Beleid omtrent GHG-emissies van biogene origine (geproduceerd door levende organismen) is nauwelijks besproken in deze beleidstukken. Een data analyse van de huidige GHG-emissie in Friesland laat zien dat de meeste emissies afkomstig zijn van biogene sectoren: landbouw en landgebruik, natuur & bosbouw. Terwijl nationaal maar 17% van de GHG-emissies toebedeeld wordt aan deze sectoren, wordt in Friesland 60% van zijn GHG-emissies toebedeeld aan deze sectoren.

Het huidige GHG-emissie beleid en de GHG-emissies zijn verder geanalyseerd in een kwantitatieve scenario analyse in het regional emission model (REM). GHG-emissies zijn berekend voor drie scenario's: Business-as-usual(BAU), PLUS en PARIS. Het huidige beleid (BAU) en verdubbelde doelstellingen (PLUS) reduceren de GHG-emissies niet genoeg om het klimaatdoel van het Parijs akkoord te halen. Het derde scenario omvat drastische maatregelen om de GHG-emissies te reduceren met 95%. Een sociaalpolitieke evaluatie is uitgevoerd door het interviewen van vijf stakeholders die de belangrijkste partijen in Friesland representeren. De bereidheid voor het bediscussieerde biogeen GHG-emissiereductie beleid was lager dan die van energie-gerelateerd GHG-emissie beleid. Compensatie voor inkomstendaling en publieke opinies over technologieën kwamen naar voren als belangrijke conflicterende belangen.

Beleid en doelstellingen geven vertrouwen in het vermogen van Friesland om de energie-gerelateerde GHG-emissies geëlimineerd te hebben in 2050. Echter, belangrijke uitdagingen moeten worden gezocht in de reductie van biogene GHG-emissies.

LAY SUMMARY

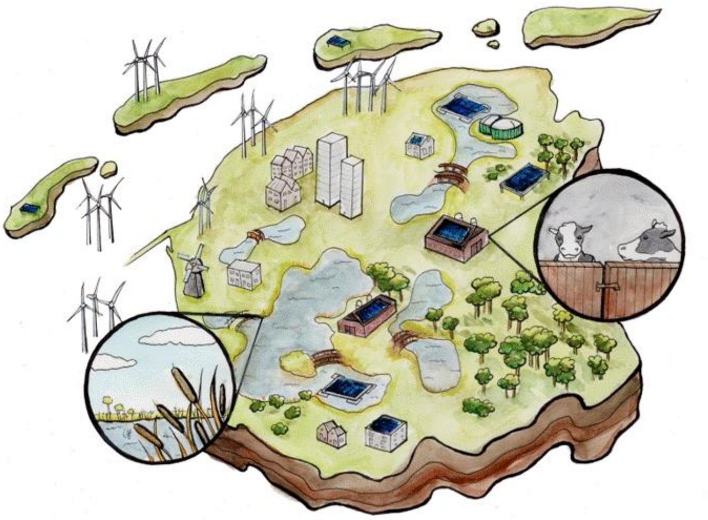


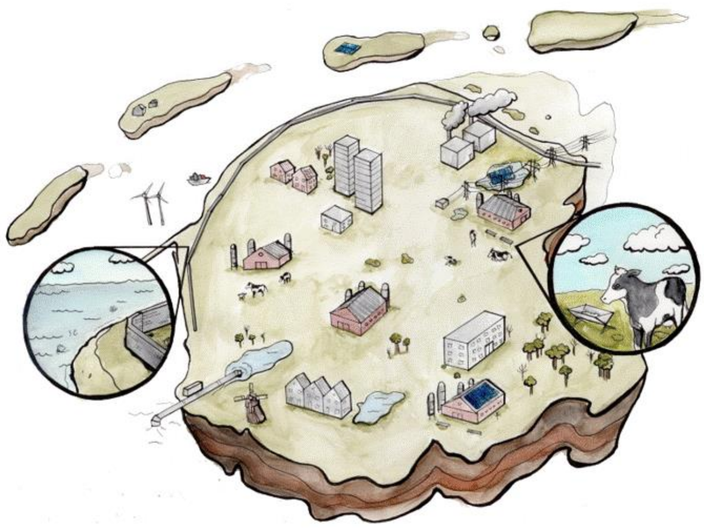
Friesland now. In the northeast, there are only barely used two gas-fired powerplants. In the southwest, there are peat-meadows and lakes. Dairy farms scatter around the province

Friesland nu. In het noordoosten staan twee gasgestookte elektriciteitscentrales die weinig gebruikt worden. In het zuidwesten zijn veenweidegebieden en meren. Melkveehouderijen zijn op verschillende plaatsen in de provincie te vinden.

Friesland in 2050 if PARIS scenario measures are implemented. The peat-meadow area has a much higher water level. In the southeast a large area is reforested. Cattle are placed in methane capturing stables.

Friesland in 2050 als de maatregelen uit het PARIS scenario worden uitgevoerd. Het veenweidegebied heeft een veel hoger grondwaterpeil. In het zuidoosten wordt een groot stuk herbebost. Rundvee staat in een stal die methaan opvangt.





Friesland in 2100 with continuous GHG emissions. Because of the rising sea levels and ground subsidence, the dykes have to be heightened and in the northeast salinization of the soil is taking place. Cattle have to be fed.

Friesland in 2100 met doorlopende broeikasemissies. Door de zeespiegelstijging en bodemdaling moeten de dijken worden verhoogt en raakt het noordoosten verzilt. Rundvee moet worden bijgevoerd.

1. INTRODUCTION

1.1 Greenhouse gas policies

In 2016 the Netherlands signed the Paris climate agreement. In this agreement, the Netherlands pledged to reduce greenhouse gas (GHG) emissions by 49% in 2030 and 95% in 2050, compared to the emissions in 1990 (Vuuren van et al., 2017). To make sure that the goals of this agreement are met, local climate-related initiatives are encouraged. This encouragement is signified in the framework “regional energy strategy” (RES) (Dutch: regionale energiestrategie) in the Dutch climate agreement (Dutch: klimaatakkoord). In this framework, the Netherlands is divided into 30 regions. Every region has to make plans for development of local renewable energy generation (Klimaatakkoord, 2018). The province of Friesland is one of these regions. Within the preliminary plan, Friesland agreed to the ambition of being energy neutral by 2050 (Provincie Fryslân, 2017a). This Frisian ambition surpasses the national policy regarding renewable energy generation. However, this ambition is limited to energy use: Friesland does not take other sources of GHG emissions into account. Could Friesland go further and achieve GHG emission neutrality by 2050?

1.2 Friesland

Friesland has four major characteristics that influence the relative amount of GHG emissions. First, Friesland is less urbanized than average with the second lowest population density of the Dutch provinces (CBS, 2019). A lower population density is associated with higher levels of GHG emissions per capita from transport and residential heating (Liddle, 2014). Secondly, there is a lower amount of non-agricultural industrial activity in the province compared to the Dutch average. Two gas-powered power plants are only used during high-energy demand or extraordinary circumstances (Leeuwarder courant, 2015). The relative absence of the non-agricultural industry and power plants is associated with lower GHG emissions. Thirdly, the rural character of Friesland is pointed out by the extent of Frisian agriculture. The fertile clay soil in the north and grasslands in the middle and the south of the province are extensively used for agriculture. The grasslands are used for the exploitation of cattle and other livestock (Everink et al, 2009). CH_4 and N_2O emissions from cattle and other livestock account for a substantial share of the total global GHG emissions (Gerber et al, 2013). Crop cultivation is exploited in the northern clay in Friesland is to a lower extent associated with GHG emission (Everink et al, 2009). Options to reduce GHG emissions in agriculture are limited (Wollenberg et al, 2016; Gerber et al, 2013; Franks & Haddinkham, 2012). Maintaining or increasing food security additionally limits options for the reduction of GHG in agriculture (Benetzen et al, 2016). Lastly, GHG emissions of land use are abundant in Friesland. Friesland is known for its many lakes in the south-west. Inland waters often have substantial CH_4 emissions (Bastviken et al, 2011). Friesland also has the largest surface area of peat-meadow lands of all Dutch provinces. Low water levels in peat-meadow land cause the peat to oxidize. This results in substantial GHG emissions. The estimated value of peat-meadow emissions in Friesland are 1.655 Mton CO_2 (Lof et al, 2017). For comparison: the estimated Frisian CO_2 emissions, excluding land use, are 4.6 Mton CO_2 in 2016 (Provincie Fryslân, 2017a).

1.3 Aim of the research

This research aims to consider Frisian GHG emission policy. All emissions of CO_2, CH_4 and N_2O are included in a scenario study for the timeframes of 2030 and 2050. A model is constructed from technical aspects of current emissions and policies. Analyzed scenarios in this model are based on targets and planned policies. The positions and interests of stakeholders on the different scenarios arevisualized to analyze the political aspects.

1.3.1 Research question

What are technical and political possibilities and constraints in environmental policy for the province of Friesland to contribute to the Paris agreement emission reduction goals for 2030 and 2050 considering CO_2, CH_4 and N_2O emissions?

1.3.2 Sub questions

1. What are the current sectoral CO_2, CH_4 and N_2O emissions of Friesland?

2. What are the current emission reducing policies for Friesland?

3. What are relevant scenarios for reducing GHG emissions for Friesland based on technological possibilities and constraints for 2030 and 2050?

4. What are the opinions of relevant stakeholders on the different policies and technologies presented in the scenarios?

1.4 Methods

Each sub question will be answered consecutively in a separate chapter. The first sub question is answered by performing a data analysis. The emissions of CO_2, CH_4 and N_2O are combined to total GHG emissions in Friesland in CO_2eq. For the conversion to CO_2eq, the 100 year equivalent conversion factors 28 and 265 are used for respectively CH_4 and N_2O (IPCC, 2014). The most used source for emissions is the emission registration database (Dutch: Emissieregistratie.nl). Missing data are added from literature. Only emissions considered by the IPCC standard are used. These data are divided into sectors. This sector division is further used throughout this report. Emissions are validated by comparing with literature and the climate monitor database (Dutch: Klimaatmonitor.nl).

The current emission reducing policies are investigated in a policy analysis to answer the second sub question. For this policy analysis, policy documents by the national government and the provincial government are referred. All emission reducing policies are presented in a table with information on: the intention, timeframe, enforcing party and source.

The third sub question is answered by a quantitative scenario analysis. This analysis is carried out to investigate the technical potential for GHG emission reduction and the effect of different policies on GHG emission reduction. Scenario studies offer a proper method of analyzing climate policy. Well-known are the elaborate global scenario studies by the IPCC. Smaller scale scenario studies of energy neutral municipalities have also been carried out. The island of Samso aims to be energy neutral by 2030 (Jantzen et al, 2018). The municipality of Groningen is aiming to be energy neutral, but considers the timeframe of 2035 (Visser, 2014). Benders et al (2011) carried out a scenario study for the energy sector on a regional level: the three northern provinces (including Friesland) of the Netherlands. This last research only used the energy part of the Regional Emission Model (REM). However, there is also a separate biogenic part available. In this study, specific for Friesland, three scenarios are made for both parts of the model. From the different scenarios the GHG emission reduction by 2030 and 2050 are investigated.

The scenarios are socially and politically assessed by a stakeholder analysis for answering the fourth sub question. Five organizational representatives are interviewed for this analysis. These representatives are a general reflection of the stakeholders in Friesland. The interviews focus on the influence on GHG emission reduction policies and on the opinions on different policies, technologies and scenarios. The opinions of the representatives are visualized in a table. Challenges, hurdles and opportunities of policy development related to stakeholders are examined from the interviews and from literature.

1.5 System boundaries

For the boundaries of GHG only CO_2, CH_4 and N_2O are considered. Fluor gases are excluded in the calculations for CO_2eq. Only GHG emissions in Friesland are investigated. Emitted GHG by Frisian citizens outside of Friesland are not considered. GHG emissions by non-Frisian citizens in Friesland are taken into account. Short-cycle CO_2, international flights and international shipping emissions are excluded according to IPCC GHG emission standards. Only the timescale of 2030 and 2050 are considered. Only the meso-scale of policies is considered. The meso-scale is the level of relations between individual stakeholders. The meta-scale; i.e. the context of the Dutch policy system, is outside of the borders of the research.

2. CURRENT GHG EMISSIONS

2.1 Introduction

In this chapter, the current GHG emissions in Friesland are derived in a data-analysis of available databases and literature. First, the used sector division is laid out. Secondly, the available databases and literature are examined. Last, the current GHG emissions in Friesland are presented.

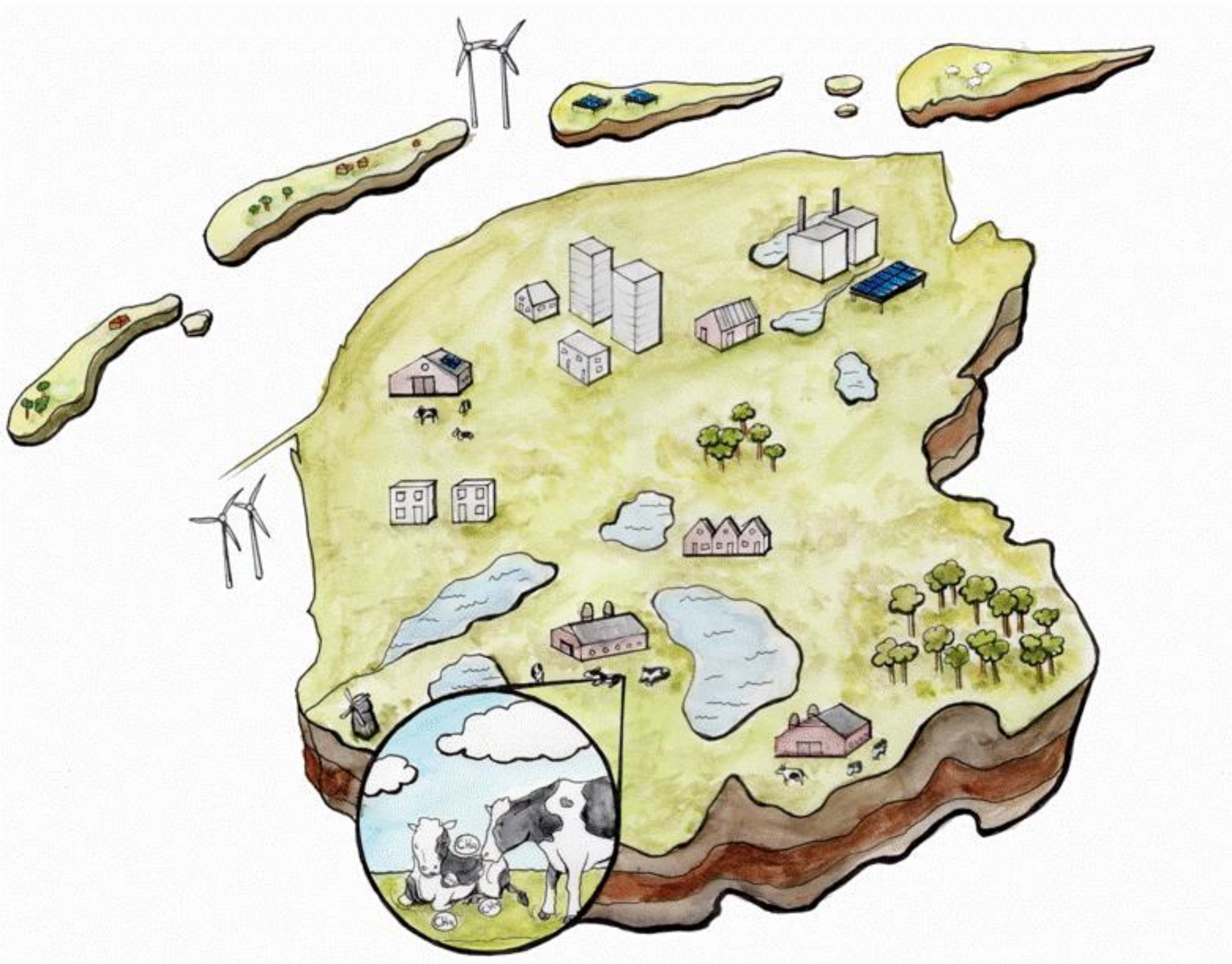


Figure 2.1-1: Friesland now. There are two barely used gas-fired powerplants in the northeast. In the southwest, the landscape consists of peat-meadows and lakes. Dairy farms scatter around the province. In the southeast, there is a woody area. Drawings by Leonie Belt.

2.2 Sector divisions

A division of the GHG emissions of sectors is used to provide insight in the causes of GHG emissions and their relative importance. The Emission registration database has its data divided into 13 sectors. The sectors with little relevance in Friesland are merged to the here used sector division (*table 2.1 - 1*). The six sectors remaining in this new division still have their own identity.

Table 2.1 - 1: Emission registration and merged sector division. Left are the original sectors from emission registration, right are the six merged sectors used in this research.

Emission registration sector division	Merged sector division
Agriculture	Agriculture
Chemical industry	Industry
Energy generation	
Other industry	
Refineries	
Mobility	Mobility
Nature	Landuse, nature and forestry
Drinking water supply	Residential area
Construction	
Consumers	
Trade, services and Government	
Waste disposal	Waste disposal
Sewage and water treatment plants	

2.3 Database used

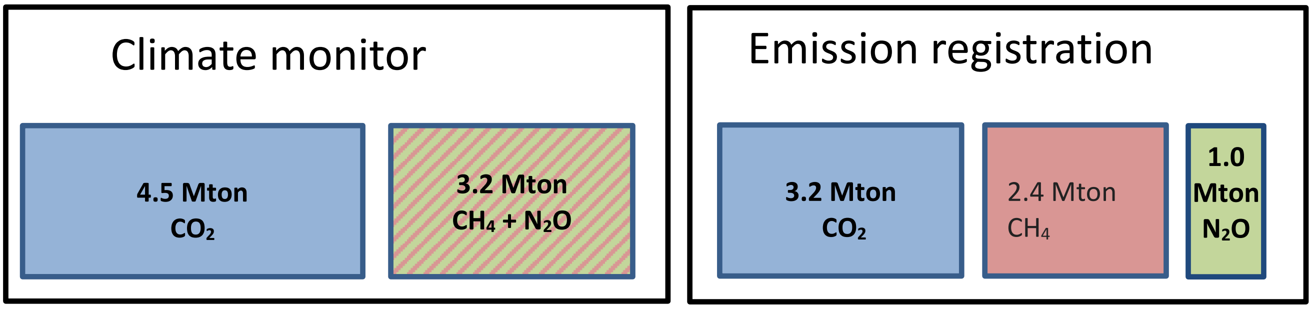


Figure 2.3 - 1: Difference in GHG emission in Friesland between climate monitor and emission registration emissions. Numbers are in CO_2eq.

Currently Friesland uses the information from the national governments Climate monitor (Dutch: klimaatmonitor) to track the GHG emissions in the province (Provincie Fryslân, 2017a). The estimated CO_2 emissions in Friesland is 4.6 Mton CO_2 in 2015, excluding peat-meadow emissions (Klimaatmonitor, 2018). CH_4 and N_2O emissions are estimated at a total of 3.2 Mton CO_2eq in 2014. It is unclear whether the GHG emissions from the climate monitor are according to the IPCC standard or to the Dutch standard. The Dutch standard would include emissions that should not be included under the guidelines of the 5th IPCC report (IPCC, 2014). Emission registration is another database that has data on GHG emissions in Friesland. Contrary to the Climate monitor, Emission registration has data on individual GHG emissions. The latest final data for Emission registration is 2015.

Aggregating the data from Emission registration shows 3.2 Mton CO_2, 2.4 Mton CH_4 (CO_2eq) and 1.0 Mton N_2O (CO_2eq) for 2015 in the IPCC standard. Emission registration has information on GHG emissions on the level of source emissions. Their data is based on mandatory emissions reports from individual firms. For emissions where no reports are available, estimates based on appropriate statistical methods are used (Emissieregistratie, 2018). The emissions are calculated for the Netherlands as a whole with an uncertainty in the national emissions of 3% for CO_2, 25% for CH_4 and 50% for N_2O. A distribution key is used to allocate the national emissions to the different provinces. The national level of uncertainty can therefore not be applied to the provincial emissions.

2.4 Landuse, nature and forestry

The emission registration database is lacking data for landuse and landuse change and forestery (LULUCF) emissions, here further called Landuse, nature and forestry (LNF). Parts of the missing emissions are added from literature (*table 2*.1.3 -1). LNF CO_2 emissions are unavailable in the emission registration database. Lof et al., 2017 calculated carbon emissions from peat-meadow lands and total carbon sequestration for all provinces of the Netherlands. The emissions from peat meadow lands are calculated on 1.655 Mton CO_2eq for 2016 for Friesland. This is similar to the estimation of 1.5 Mton CO_2eq by Janssen et al., 2013. Peat-meadow GHG emissions are the major source of LNF GHG emissions. The total national LNF emissions are 8.82 Mton CO_2 of which 6.91 Mton CO_2 are from peat-meadow soils (RIVM, 2018). Other LNF CO_2 emissions are not available for Friesland specific and are therefore not considered. Carbon sequestration is available for Friesland and is estimated at 0.33 Mton CO_2 sink for the province of Friesland in 2016 (Lof et al., 2017). Emissions from inland water are not considered, because of the lack of data (RIVM, 2018). Inland waters often have substantial CH_4 emissions (Bastviken et al, 2011). Estimating an amount is not possible as variation within and between water body types is large (Schrier-Uijl et al., 2011). Therefore current CH_4 emissions from inland water are not taken into account for landuse emission. N_2O emissions from non-agricultural land area is considered in the landuse sector. N_2O emissions from agricultural area is considered in the fertilizer subsector in the agricultural sector in the emission registration database.

Table 2.3 - 1: Considered landuse, nature and forestry emissions in Friesland. There are three area types: agricultural land, non-agricultural land and inland water. Peat-meadow and sequestration emissions are not divided per area and are added to the total Landuse, nature and forestry emissions.

Emissiontype	Emissions	Data	Source
Agricultural land	CO_2	Only peat-meadow and sequestration considered	-
	CH_4	0.179 Mton CO_2eq	Emission registration database
	N_2O	Included in agricultural sector	Emission registration database
Non-agricultural land	CO_2	Only peat-meadow and sequestration considered	-
	CH_4	0.047 Mton Co_2eq	Emission registration database
	N_2O	0.053 Mton CO_2eq	Emission registration database
Inland water	CO_2	No specific data available, not considered	-
	CH_4	No specific data available, not considered	-
	N_2O	No specific data available, not considered	-
Peat-meadow	CO_2	1.655 Mton CO_2eq	Lof et al., 2017
Sequestration	CO_2	-0.33 Mton CO_2eq	Lof et al., 2017

2.5 Results

The total greenhouse gas emissions in Friesland are calculated at 7.86 Mton CO_2eq. This is about 3.7% of the national GHG emissions. The share of the national population is 3.8%, thus the GHG emission per capita in Friesland is similar to the GHG emissions per capita in the Netherlands. The sectors of mobility, residential area and waste disposal are proportional to the national emissions (*figure 2.5-1*). However, there are large differences in the industry, agriculture and LNF sector. Agriculture is the sector with the largest share (40%) of GHG emissions in Friesland. The whole of the Netherlands has 14% of its GHG emissions in this sector. Also the share of LNF sector is multiple times larger in Friesland (20%) as compared to the Netherlands as a whole (3%). This is compensated by the large share of the industry sector in the Netherlands (48%). Friesland has only 5% of its GHG emissions in the industry sector.

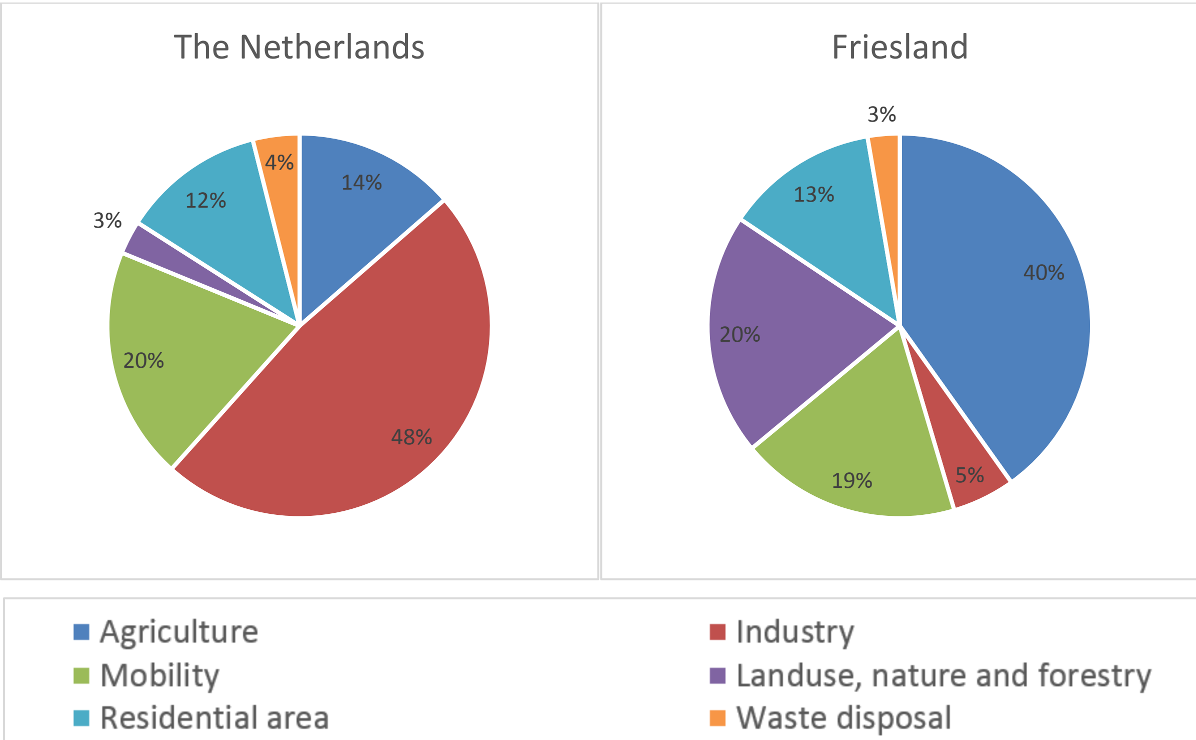


Figure 2.5-1: Comparison total GHG emissions the Netherlands and Friesland.

The agriculture and LNF sector have predominately biogenic (emitted by living organisms) GHG emissions. CH_4 and N_2O emissions are a larger part in these sectors (*figure 2.5-2*). Nationally, CH_4 and N_2O together account for 14% of the total GHG emissions. In Friesland CH_4 and N_2O together are responsible for 43% of the total GHG emissions. The major source of this different composition of GHG emissions is the large agricultural sector and the small industrial sector in Friesland. CH_4 emissions from cattle are the largest sub-sectoral emission with little over 1.8 Mton CO_2eq. These Frisian CH_4 emissions from cattle are 17.3% of the national CH_4 emissions from cattle. Frisian N_2O emissions from animal waste are also substantial with 18.0 % of the national N_2O emission from animal waste. LNF has large emissions in peat-meadow lands. The peat-meadows in Friesland are responsible for 23.9 % of national peat-meadow emissions. Carbon sequestering is low in Friesland, as it is lacking major forests. The total forested area is only 3% of Friesland (Noorderbreedte, 2019). The small size of the industry sector can be largely explained by small activity of fossil-fuel power plants in Friesland. While electricity generation is responsible for almost a quarter of all GHG emissions nationally, electricity generation is a negligible part of the GHG emissions in Friesland (klimaatakkoord, 2018). Important to note is that GHG emissions from imported electricity is not considered, as it is outside of Friesland.

The large influence of the agricultural sector is also felt in other sectors (*appendix 8.1.2-1*). Within the industrial sector, the food industry is responsible for 65% of the total emissions. While all other industries are relatively small in Friesland, the food industry has a relative large share (6.6%) of national emissions. In the mobility sector, the subsector mobile machinery also has a relative large share (7.0%) of national emissions. Agricultural machinery such as tractors fall in this category.

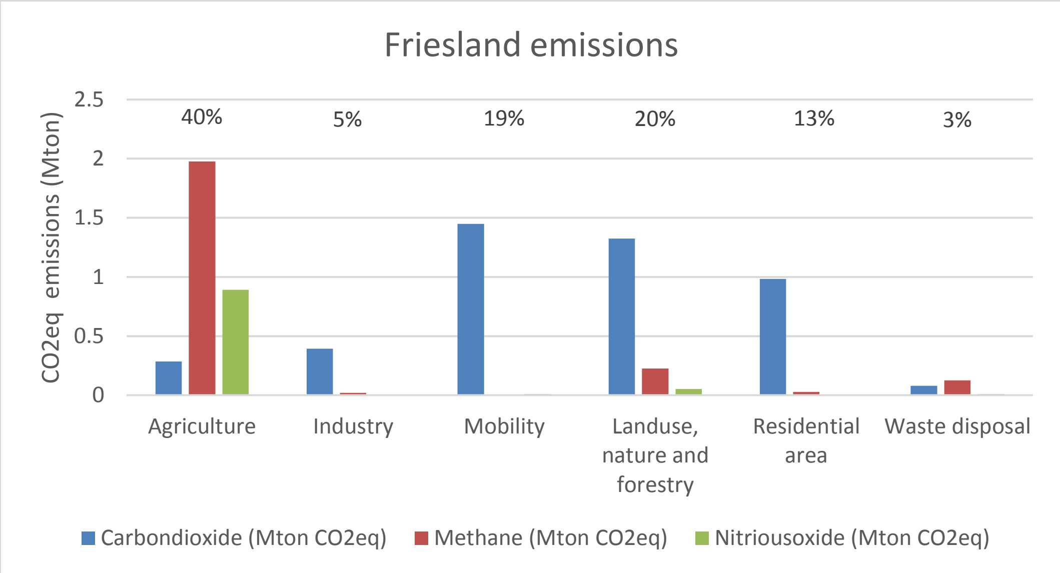


Figure 2.5-1: GHG emissions in Friesland. Percentages are the share of sectoral emissions to the total emissions.

2.6 Conclusion

GHG emission data is available in detail for all but landuse, nature & forestry sector in the emission registration database. GHG emissions in landuse, nature & forestry are supplemented from the limited available literature. In total, it shows that Friesland has proportional total GHG emissions to population. However, the fractional GHG emissions from agricultural and Landuse, nature & forestry are several times larger in Friesland. The fraction of GHG emissions from industry in Friesland is only a tenth of the fraction of national GHG emissions. As CH_4 and N_2O emissions are more represented in the agricultural and landuse, nature & forestry sector, Friesland also has a higher share of these GHG gases.

3. CURRENT GHG EMISSION REDUCING POLICIES

3.1 Introduction

In this chapter, the current GHG emissions policies are discussed. First, the different reviewed documents are discussed. Thereafter the different measures per sector are discussed.

3.2 Reviewed documents

The most up-to-date renewable energy plans are found in the implementation program 2018 (Dutch: uitvoeringsprogramma 2018). This implementation program is a continuation on the more general Frisian energy strategy (Dutch: Friese energiestrategie). Most important in these documents are the renewable energy generation targets for 2020, 2025 and 2050 (*table 3.2-1*). Assuming a linear path between 2025 and 2050, the target for 2030 would be 40% renewable energy generation. Both documents are setups toward the regional energy strategy (RES) that has to be delivered one year after the final climate agreement (VNG, 2018). Regions are free to add biogenic emission policies to the RES (Klimaatakkoord, 2018). However, Friesland does only mention energy related emissions in both documents by the province of Friesland (Provincie Fryslân, 2018 & Provincie Fryslân, 2017a). This indicates that biogenic emissions probably will not be included to the RES. Emission reduction targets for biogenic GHG emissions are found elsewhere. The national plan for all GHG emissions are found in the preliminary climate agreement (Dutch: voorlopig klimaatakkoord). Further consulted documents are the peat-meadow vision (Dutch: Veenweidevisie), policy document sustainable agriculture (Dutch: beleidsbrief duurzame landbouw) and waste management and transfer (Dutch: afvalbeheer en overbrenging). From all policy documents a table per sector containing all current GHG emission reducing policies is made with information on: the sector, intention, plan, timeframe, responsibility and source.

Table 3.2-1: Renewable energy targets in the implementation program (Provincie Fryslân, 2018).

2020	16% renewable energy
2025	25% renewable energy
2050	100% renewable energy

3.3 Sector specific policies

3.3.1 Agriculture

While the dominant GHG emissions in agriculture are the CH_4 from cattle and N_2O from livestock (*figure 2.5-1*), Friesland focusses to reduce energy use in agriculture and generate renewable energy (Provincie Fryslân, 2018). Nationally, there are targets for emission reduction for these CH_4 and N_2O emissions. Based on the Frisian share of these emissions the target for Friesland are 0.14 Mton CH_4 (CO_2eq) and 0.03 Mton N_2O (CO_2eq) emission reduction by 2030 (*appendix 8.2.1*). This reduction should be achieved by using newer technologies in animal feed and manure treatment (Klimaatakkoord, 2018). Further information agriculture policy can be found in *appendix 8.2.1-1*

3.3.2 Industry

The focus for GHG emission reduction in the industrial sector is reducing energy consumption and change energy use to renewable energy sources. There are already policies in place to stimulate energy use reduction. Companies are obligated to implement energy use reducing investments that are cost-effective within 5 years. Larger companies are within the Emission Trading System (ETS) or long-term agreements on energy efficiency (Dutch: MJA). There are companies in Friesland presented in both systems (MJA3-Deelnemerslijst, 2019 and emissiecijfers industrie 2013-2017, 2018). Currently the energy use reduction potential for individual companies are being mapped and the execution of policies are monitored (Provincie Fryslân, 2018). For the future, the focus is on including companies in renewable energy generation projects. Projects in using residual heat or other waste streams are encouraged. Nationally carbon capture and storage (CCS) is considered large part in reducing CO2 emissions, but in Frisian policy documents, CCS is not considered for a CO2 emission reduction. CCS is further discussed in 4.6. Further information industry policy in *table 8.2-2*

3.3.3 Mobility

Public transportation exploiters have to be CO2 emission free by 2025. Friesland adepts a limited role in reducing GHG emissions in private transport. There are plans on building charging stations for electric cars at carpool locations (Provincie Fryslân, 2018). According to the national target, no new passenger cars and two-wheeled vehicles sold by 2030 have GHG emissions. Emissions from heavy transport traffic and agricultural vehicles are reduced by using biofuel blends and energy use reducing technologies (Klimaatakkoord, 2018). Furthermore, use and availability of public transport and bicycles are promoted. Further information mobility policy in *table 8.2-3*

3.3.4 Landuse, nature and forestry

Currently the Frisian water board drains most of the peat-meadow area in Friesland (Provincie Fryslân, 2015). Because of CO_2 emissions and soil subsidence, area-specific policies for peat-meadows are being implemented (*figure 3.3.4-1*). Peat thickness is the main new policy driver, but soil composition and location also play a role. Generally: where the peat layer is thinner than 80 cm, draining will continue and where peat layer is thicker than 80 cm, additional policies are in place. Additional policies are restricted drainage and higher water levels in summer. Furthermore, underwater drainage is tested and overturning of soils is reduced. In specific target areas, maximum policies are in place. In those target areas water level is higher and there are experiments with wet crops. Further information LNF policy in *appendix 8.2-4*.

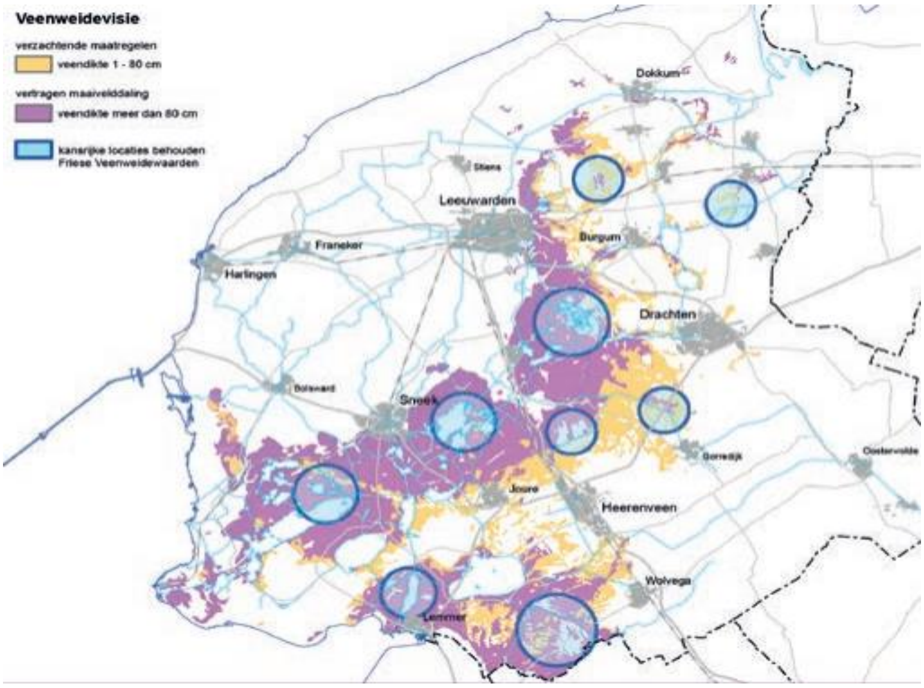


Figure 3.3.4-1: Peat-meadow policies. Yellow is peat thinner than 80 cm, purple is peat thicker than 80 cm and encircled areas are target areas (Provincie Fryslân, 2015).

3.3.5 Residential area

The main GHG emissions (97%) from the residential sector are from energy consumption of buildings. Current plans are about building new buildings energy neutral and making existing houses more sustainable (Provincie Fryslân, 2018). For 2050, all buildings should be energy neutral, as in the sense that yearly energy consumption is equal to yearly energy generation. Buildings are better isolated and depending of the local surroundings and the age of buildings, system choices are made for energy generation. Predominant is the all-electric system. Other options are the geothermal, biogas and biomass dependent systems (Provincie Fryslân, 2017a). There are additional intermediate goals for governmental buildings and housing associations. All governmental buildings should be energy neutral by 2025, to be an example for other sectors. Housing associations have intermediate goals using the Dutch “energy label” system. Energy consumption reducing improvements to buildings are stimulated by the availability of green loans and the availability of a sustainable construction counter. By aggregating projects efficiency can be increased, costs can be lowered and loans are less risky and thus easier granted. Further information residential area policy in *appendix 8.2-5.*

3.3.6 Waste disposal

Waste disposal is not considered in the implementation plan and national climate agreement. The national plan for waste disposal is waste management and transfer. The current state is seen as a transition state towards a fully circular economy. More and more waste products will be reused. Leftover waste is incinerated for energy production. Salt producer Friso uses the heat produced by the waste incinerator at Harlingen (Provincie Fryslân, 2017a). Old landfills still have organic waste that emit CH_4, but emissions decreased the previous decade (DGMI, 2017). These CH_4 emissions will continue to decrease as no new organic waste is landfilled. Further information waste disposal policy in *appendix 8.2-6.*

3.4 Conclusion

Most of the current GHG emission reduction policies in Friesland focus on energy-related emissions. The guideline for policy in reducing energy-related GHG emissions is trias energetica (Provincie Fryslân, 2018). First, energy use is reduced. Second, energy generation increasingly comes from renewable sources. Third, fossil fuels are used more efficiently. These three measures are found in the four sectors dealing with energy-related emissions: Agriculture, Industry, Mobility and Residential area. Overall, plans for energy-related emissions are quite elaborate. Plans for biogenic GHG emission reduction are scattered in different policy documents. These policy documents do not all relate specifically for Friesland and are generally quite vague.

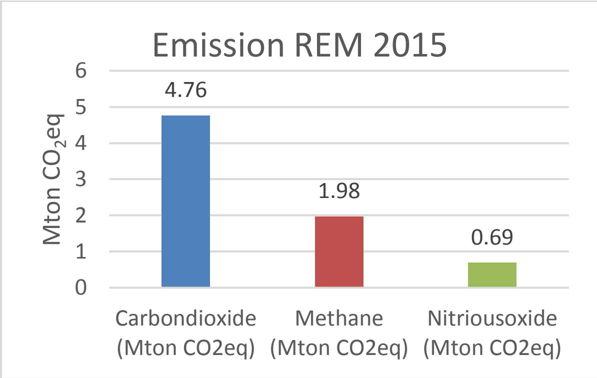
4. SCENARIO ANALYSIS

4.1 Introduction

In this chapter, the scenario analysis is treated. First, the REM model is discussed and validated. Secondly, the setup of the three energy-related scenarios and the three integrated-scenarios: BAU, PLUS and PARIS are discussed. Thereafter, the results from the energy scenarios and the integrated-scenarios are shown. Energy security and biomass are discussed last. Details are found in the *appendix 8.3*.

4.2 REM

The applied version of the Regional Emission Model (REM) has an energy part and a biogenic part (Bouwman et al, 1992; Toet et al, 1994).The energy part is calculated bottom-up, the biogenic part is calculated with a mixture of bottom-up and top-down. Both the energy and biogenic parts use the parameters in the input file, but do not interact in any other way. Starting parameters are based on the emissions calculated of 2015 in Chapter 2, on data available literature and databases or on input for REM of earlier applications (*appendix 8.3.1-1 and appendix 8.3.1-2)*. From the starting parameters, the starting year of 2015 is calculated. REM calculates the parameters of all consecutive years up to 2050. Not all output for the parameters in 2050 is influenced in a similar manner. Parameters are either influenced by end-year values, yearly growth values or a combination of both. Yearly growth values are either in the form of a single number equal for every year or a timeseries in which the growth in time can be changed. Within the biogenic part of REM, Friesland is build up in different area types. Grasslands are filled with cows and agricultural lands are filled with agricultural activity. Fertilizer is distributed over these grasslands and agricultural lands. To decrease the amount of cows, the grassland area has to be reduced. All other parameters directly affect their respective target emissions. In the energy part of REM, energy use and emissions per sector are calculated. These sectors are not equal to the sectors used in chapter 2. In addition, the energy related emissions of agriculture are used in the energy part of the model and the biogenic emissions are used in the biogenic part of REM. However, the division of the emissions of chapter 2 to subsectors allows enough detail to split emissions to the sectors used in the energy part and to split the emissions used in the energy part and the biogenic part. The objective of Friesland is to be fully energy neutral by 2050. Friesland mentions the trias energetica and focusses mainly on reducing energy consumption. In REM this is achieved by better insulation and high penetration of more efficient technologies such as LED lighting as opposed to conventional lighting. All transportation is electrified in 2050, save for inland shipping, which uses biomass. Industrial and waste disposal high temperature is generated by the use of biomass. Validation of the starting year is done by comparing the emissions of the first year in the model to the emissions in chapter 2 (*figure 4:2-1*). The model calculates lower CH_4 and N_2O and higher CO_2 emissions. The differences lie within the margin of error of the data of Emission registration (Emissieregistratie, 2018).



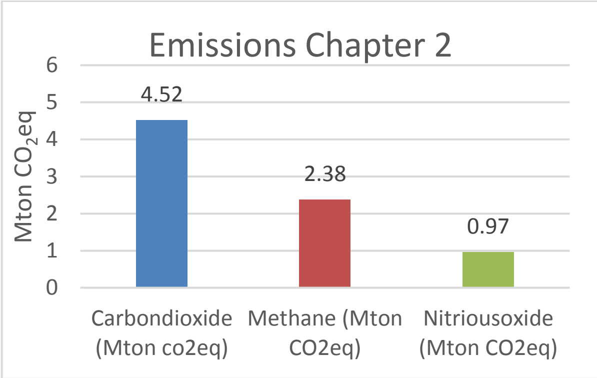


Figure 4.2-1: Comparison emissions REM and results chapter 2 in 2015.

4.3 Scenarios

To study differences in choices of technologies that can be used to become energy neutral, three energy-scenarios have also been constructed (*figure 4.3-1*). The province of Friesland expects a portion of electricity could be generated using geothermal energy. The geothermal scenario is based on that assumption. Friesland also expects that 30% of the heat requirement can be met with geothermal energy. The biomass scenario replaces this geothermal energy with biomass energy and uses 30% biomass in non-residential hot water. The full electric scenario uses only renewables for electricity generation and electricity for its heat demand. For the energy-scenarios the current emissions from electricity use are considered, even though these emissions are emitted elsewhere. Adding these GHG emissions allows for examining the effect of GHG emission reduction elsewhere with different electricity generation regimes. In all integrated-scenarios, the emissions from the full-electric scenario without the emissions from electricity generation are used. Only the 2030 GHG emissions are relevant as there are no GHG emissions in 2050 in any of the energy-scenarios.

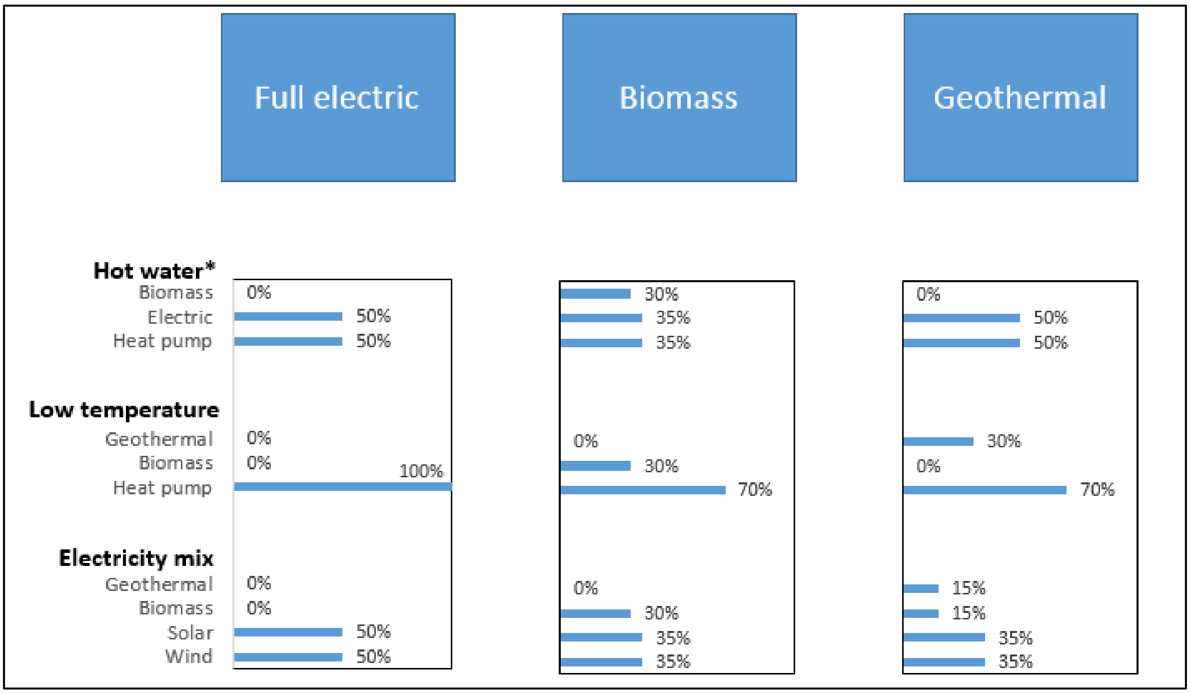


Figure 4.3-1: Differences among energy-scenarios. The scenarios differ in the categories: hot water, low temperature and electricity mix. *Hot water is only for the residential sector.

There are three integrated-scenarios: business-as-usual (BAU), PLUS and PARIS (*figure 4.3-2*). The BAU scenario is policy of 2050 if available or policy of 2030 that is continued. For the continued policy of 2030, the 2050 targets were three times the 2030 targets. In the PLUS scenario peat meadow emissions are reduced according to the most far-reaching scenario in the peat-meadow vision (Provincie Fryslân, 2015). All other measures are doubled compared to the BAU scenario. The PARIS scenario is result oriented: what measures would reduce GHG emissions with 95%.

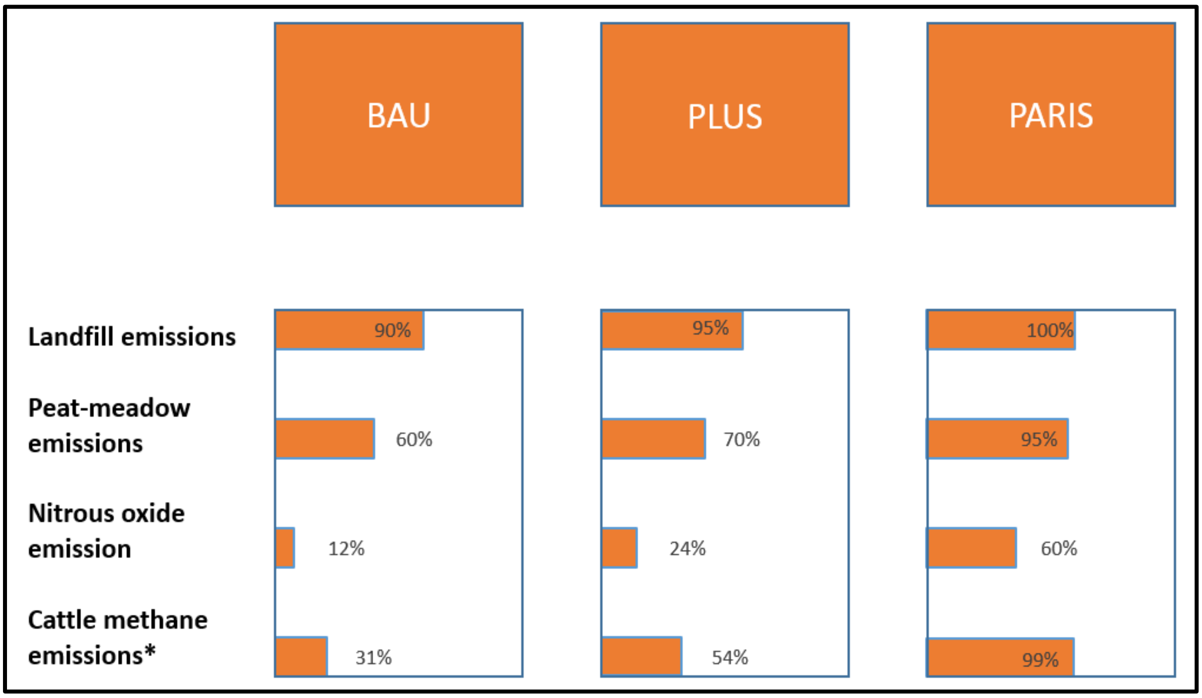


Figure 4.3-2: Differences in emission reduction among integrated-scenarios. The scenarios differ in the categories: landfill emission, peat-meadow emissions, nitrious oxide emissions, cattle methane emissions and reforestation (not depicted). Percentage are the total emission reduction in these categories in 2050 compared to 2015. *Cattle methane emissions includes the effect of amount livestock reduction and manure treatment. *Appendix 8.3.3-1* shows more detailed the setup of the integrated-scenarios.

The measures for the PARIS scenario include additional measures not mentioned in policy documents. A detailed list of measures is found in *appendix 8.3.2-1*. A major additional measure in the PARIS scenario is the 85% reduction of livestock in 2050 compared to 2015. All further technological possibilities are fully implemented in animal waste management, cow methane emissions and landfill methane emission. Additionally, peat-meadow emissions are reduced to 5% of their value in 2015 and nitrous oxide emissions are reduced to 40% of their value in 2015. Reforestation efforts are tripled compared to the BAU scenario.

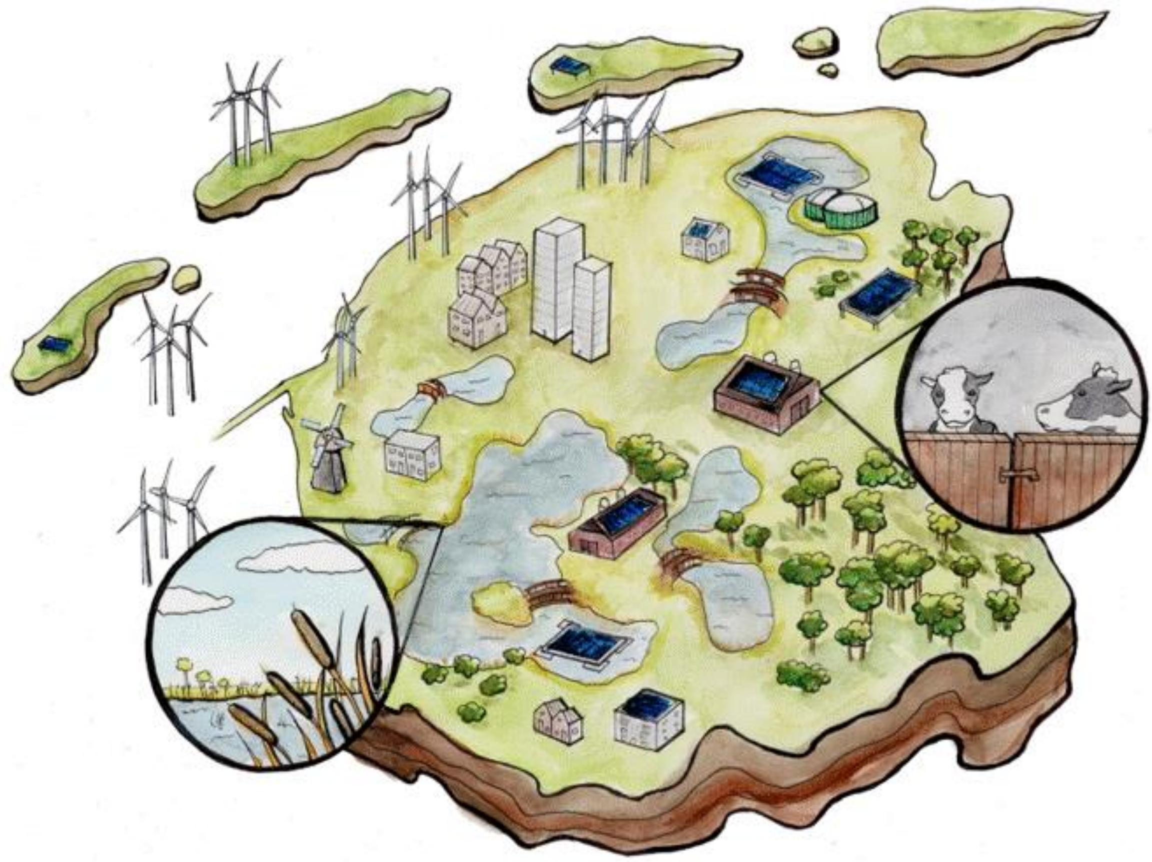


Figure 4.3-3: Friesland in 2050 in implementing the PARIS scenario measures. The peat-meadow area has a much higher water level, flooding large parts of the province. In the peat-meadow area cattails are grown for biomass production. In the southeast a large area is reforested for carbon sequestration. Cattle are placed in methane capturing stables. The amount of cattle is reduced.

4.4 Results

The energy-scenario are calculated with GHG emission from electricity generation. There is a minimal difference in CO_2 emissions by 2030 (*appendix 8.3.4-1*). The difference can be explained by adaptation rate to new energy technologies. Biomass technologies are more alike to the current power plants and heating technologies, thus can be employed faster. The other two scenarios employ technologies towards 2050 that are more different from the technologies used in the start year, with geothermal energy being the most different. Primary energy use differs more among the scenarios. Electricity technologies are generally more efficient than their biomass or geothermal counterparts. This is especially true for heat pumps. Therefore the primary energy use in the full electric scenario is lowest. The renewable capacity targets for Friesland for 2025 are 530 MWp of onshore wind and 1300 MWp of solar PV (Provincie Fryslân, 2018). Compared to these targets in 2025, onshore wind capacity doubles in the full electric scenario and is 1.5 times larger in the biomass and geothermal scenario (*figure 4.4-2*). Compared to the target in 2025, solar PV capacity only needs to increase about 300 MWp for the biomass and geothermal scenario. For the full electric scenario, a 1000 MWp increase in capacity is needed.

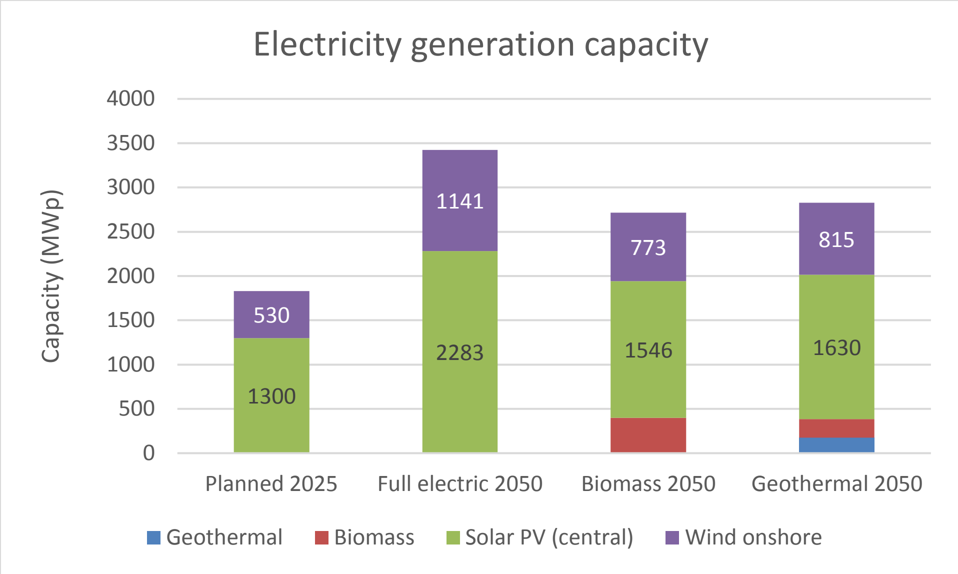


Figure 4.4-2: Onshore wind and solar PV capacity in the scenarios. All three scenarios require an increase of the 2025 capacity of wind and solar energy in 2050.

All results of the energy and biogenic part together are shown in *appendix 8.3.5-1*. The GHG emissions in 2050 are shown in *figure 4.4-1.* For the energy part of the emissions, the full electric scenario is used. The BAU and PLUS scenarios reach respectively a reduction of 77% and 83%. Only the scenario specifically designed for it meets the goal of 95% reduction by 2050. While CO_2 is the largest contributor to the total GHG emissions in 2030, methane overtakes that position in 2050 for the BAU and PLUS scenario. The PARIS scenario has N_2O emissions as the major contributor in 2050. In this scenario, there is even CO_2 uptake, because of reforestation outweighing peat-meadow emissions. In 2030 only the BAU scenario does not achieve 49% reduction.

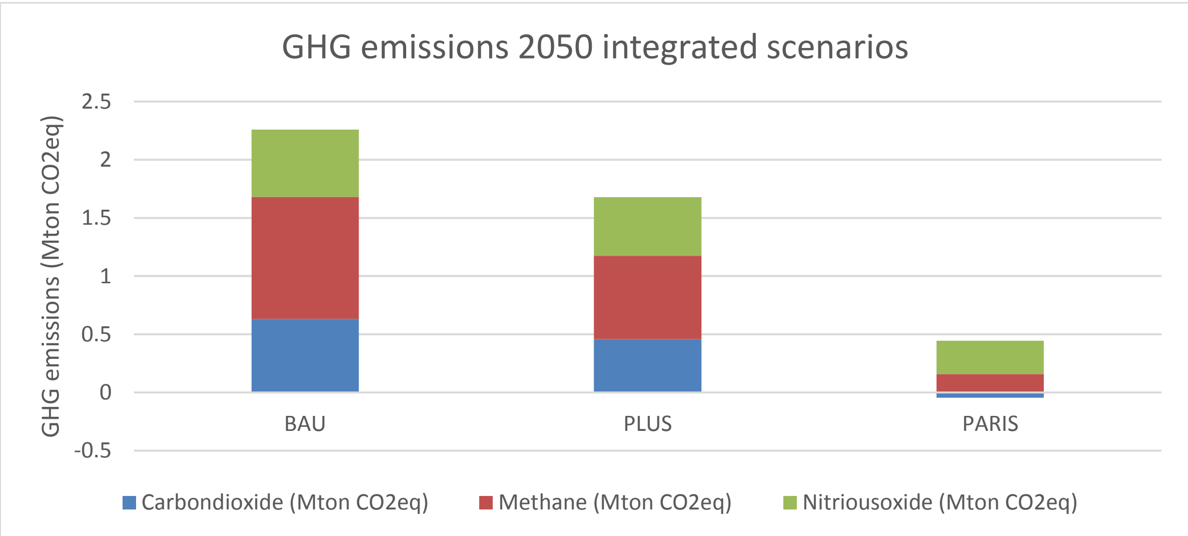


Figure 4.4-1: The absolute GHG emissions 2050.

4.5 CCS

Friesland has many empty gas reservoirs that are relatively cheap and safe to exploit for CCS (Ramirez et al, 2010). Most of them are located in the sparsely populated northeast and some of them are located in the more urbanized and more industrialized heart of Friesland. CCS could be used to store emissions from the current limited industry and electricity generation plants in

Friesland. A new biomass electricity generation plant with CCS could also be a future option for Friesland. Such a plant could serve as a CO_2 sink and could be feasible together with a carbon pricing policy (Carbo et al. 2011).

4.6 Reforestation and wet crops

The biomass used for electricity and energy production is from the plant Typha latifolia. This fast growing cattail grows in or near water, thus is suitable for cultivation in high water-level peat-meadow lands (Ciria et al, 2005). If 60% of the current peat-meadow lands would be used for biomass cultivation, it would produce enough biomass for the geothermal scenario, and half the biomass necessary for the biomass scenario (*appendix 8.3.6-1*). Such a system would reduce GHG emissions on three fronts. Emissions in the energy sector would reduce, as well as emissions from peat-meadows and the cows grazing on these meadows. However, the size of the peat-meadow area is not enough to provide all biomass in the biomass scenario (*appendix 8.3.6-1*).

Reforestation could also be used for biomass in such a system. In the PARIS scenario, more than 10% of Friesland would be reforested. This would result in 4 times as much forest as there is today. Biomass from this forest could be used for energy production. The combined biomass potential of both the forest area and the peat-meadow area is enough for the biomass scenario (*appendix 8.3.6-1 and 8.3.6-2)*. The estimated 1.9 Mton of short cycle CO_2 in this biomass (*appendix 8.3.6-3*) could be used for carbon capture and storage (CCS).

4.7 Energy security

Energy security is not included in the model. The complexity of matching production and demand on every moment of the day is left out. In *figure 4.7-1*, a yearly pattern of the production of electricity in the full electric scenario is matched with a yearly pattern of demand in Friesland. Variability in production matched to demand ranges from more than 800 MW underproduction to more than 1700 MW overproduction (*section 8.3.7)*. Balancing such a system internally would require an extremely large electricity storage capacity. Balancing such a system externally would require high international integration of electricity networks and even then, electricity storage would be required. Electricity storage and transportation have losses associated with them. The total yearly overproduction is about 5.6 PJ (*appendix 8.3.7*). A potentially large storage system are all electric vehicles. All electric vehicles in Friesland would use 9.31 PJ in 2050(*appendix 8.3.4-2*). While the yearly overproduction of electricity is lower than the yearly consumption in electric cars, daily or seasonally overproduction of electricity might be higher. Yet to a certain degree, it should be possible to use the storage capacity of electric cars for balancing production and demand. No storage capacity is also an option. A larger 805 MW biomass power plant could compensate all underproduction in such a system. That powerplant would use less than 60% of the peat-meadow area for biomass production (*appendix 8.3.7-1*). All overproduction of electricity is not used in such system.

In the other scenarios, thermal energy power plants and biomass power plants can compensate the variability in production from solar PV and wind energy. The installed capacity of these thermal energy power plants and biomass power plants in the model are too low to compensate all underproduction (*appendix 8.3.4-1*). These scenarios are not further investigated.

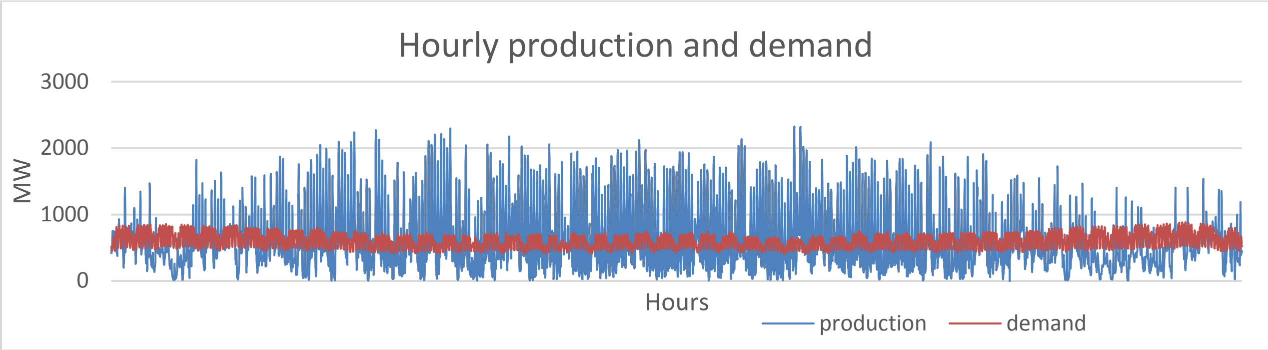


Figure 4.7-1: Electricity production and demand in the full electric scenario. Blue is the combined production of solar and wind energy with patterns from Friesland 2014. Red is an estimation of the demand pattern for the Netherlands of 2050 scaled to fraction electricity use Friesland (*appendix 8.3.7*).

4.8 Conclusion

Regional emission model (REM) is used to construct three integrated-scenarios for GHG emissions in Friesland in 2050. In this model, energy-related GHG emissions and biogenic GHG emissions are separated. As Friesland focusses on trias energetica, for the energy-related emissions energy use reducing technologies are implemented. All energy use left is shifted to full renewable energy sources at 2050 to abide the fossil fuel free objective. The different energy-scenarios show that different technologies have minimal effects on the GHG emissions in 2030. The primary energy use does differ more among the three scenarios, with the full-electric scenario using least primary energy and the biomass-scenario using most primary energy. For the biogenic emissions, the current policies and emissions targets are used. From the three integrated-scenarios: business-as-usual (BAU), PLUS and PARIS; only the last reaches the GHG emissions target. The current policies and target, or doubling the targets achieve respectively only 77% and 83% GHG emissions reduction by 2050. Biomass and energy storage are limited or not considered in the model. Biomass provides unique opportunities in combining GHG emission reduction for both energy-related and biogenic GHG emissions. Enough biomass production for the biomass energy-scenario could be produced, but land use would be substantial. The full-electric energy-scenario would need much storage to balance out the production and demand. An 820MW biomass electricity-generation plant would be enough to assure energy security. However, such a large power plant would require 39% of the area of Friesland be used for biomass production.

5. STAKEHOLDER ANALYSIS

5.1 Introduction

In this chapter the sociopolitical context of the GHG emission reducing policies id examined. First, this context and the chosen stakeholders are discussed. Second, the opinions of the stakeholders are shown for the energy-related and biogenic measure separately. At last there is a reflection on economic and social implications of the research.

5.2 Sociopolitical assessment

Assessing the technical aspects of different policies is only part of the whole policy process (*figure 5.1-1*). Many of the steps in the policy process are touched in this research. In the previous three chapter the main analyzed process is *Policy options & strategies.* Here *Policy negotiation* is discussed in a sociopolitical assessment. The main task of the province of Friesland is spatial planning (appendix 8.4.4-1). Spatial planning is important for GHG emissions policy. The province has leading voice in where to locate renewable energy production. The province determines the function of the peat-meadow area (a*ppendix 8.4.4-1 and 8.4.5-1*). The current function for peat-meadow area is agriculture (Provincie Fryslân, 2015).

The decentralization of GHG emission policy is further elaborated in the RES framework (klimaatakkoord, 2018). Studies have found mixed results with decentralized climate policy (Steuer & Clar, 2014; Hoff & Strobel, 2013; den Exter et al, 2014). These studies show that local governments are often ill equipped to handle the climate problem as a whole. As a result, there is a large dependency on individual stakeholders (Daniel et al, 2015). Therefore, the scenarios will be sociopolitically assessed by using a stakeholder analysis. This analysis will be performed at meso-scale that considers the role of stakeholders in the process.

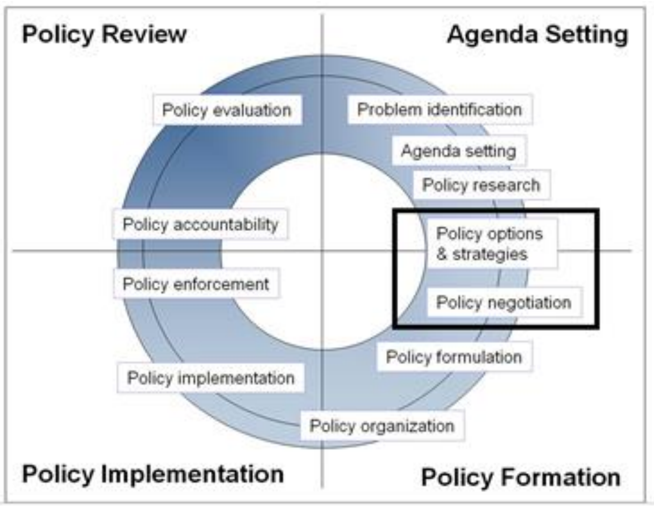


Figure 5.2-1: Policy cycle. The boxed phases are mainly examined in this research (EcoInformatics, 2018).

5.3 The stakeholders

Five representatives of different organizations are interviewed on their opinion of the scenarios and about their climate policy (*table 5.2-1*). Three of these organizations are non-governmental organizations: Energy commission north (Dutch: Energiecommissie noord), Frisian environment federation (Dutch: Friese milieufederatie(FMF)) and Agriculture & horticulture organization north (Dutch: Land- en tuinbouworganisatie Noord (LTO)). The other two are governmental organizations: Province Friesland (Dutch: Provincie Friesland) and Frisian water board (Dutch: It Wetterskip). All interviewees are local to Friesland. These five organizations are chosen based on their expertise and their relevance for GHG emissions. All organizations have environmental policy and are involved in the national talks of the climate agreement. Renewable energy generation is a main topic mentioned by the LTO and water board. The LTO actively encourage farmers to install solar panels on barns and plans the Frisian water board to be energy neutral by 2035 (*appendix 8.4.1-2 and 8.4.5-7*). The province of Friesland also mainly targets energy generation in its policy. Even though non-energy related emissions reduction is more challenging; the province prefers to put their resources in achieving energy neutrality (*appendix 8.4.4-2*).

Both the Energy commission and the FMF have a non-restricted aim to achieve maximum GHG emission reduction. While the LTO does aim for a joint GHG emission reduction, measures do need to be suitable and have to be compensated financially (*appendix 8.4.1-3*). The province of Friesland aims to achieve the climate goals, but not at the cost of public support.

Table 5.3-1: Stakeholders, Colors represent the organization (red= Agriculture and horticulture organization north, green- Energy commission north, orange- Frisian environmental federation, purple- Province Friesland and blue- Frisian water board).

Organization	Type	Name	Function
Agriculture and horticulture organization north (LTO)	Non-governmental	Trienke Elshof	Regional head of Friesland
Energy commission north	Non-governmental	Bouwe de Boer	Regional head of Friesland
Frisian environment federation (FMF)	Non-governmental	Gerard Adema	Project manager
Province Friesland	Governmental	Jan Jaap Dicke	Policy officer
Frisian water board	Governmental	Paul van Erkelens	Dike reeve

5.4 Energy model

The scenarios in the energy model are mainly dependent on its energy generation technologies. For these technologies, three interviewees were asked about their opinion (*table 5.3-1*). Solar panels as a technology has favorable potential in Friesland. Windmill were seen as a technology with more potential in Friesland (*appendix 8.4.2-1*). However, windmills generally have less public support than solar panels (a*ppendix 8.4.4-8*). The province Friesland attaches high value to public support of a technology (a*ppendix 8.4.4-5*). All three parties agreed that solar panels and windmills would be major technologies for energy generation in the future. For biomass and geothermal energy, the opinions were more divided. The FMF expressed their concerns about the potential of geothermal technology, as pilots are still running. Furthermore, the unknown effects of geothermal on the subsurface may lead to future public support related issues (*appendix 8.4.3-6*). The FMF also discourages high biomass use for energy generation, as biomass might be used more valuably in other processes. There are also problems associated with the import of biomass (*appendix 8.4.3-1*). The energy commission argued that Friesland has good potential of biomass and geothermal compared to the rest of the Netherlands (a*ppendix 8.4.2-1*). Friesland would be ideally suited for both technologies (*appendix 8.4.2-5*). The province Friesland argued in favor of geothermal energy, but was unfavorable for use of biomass (*appendix 8.4.4-7*).

Table 5.4-1: Energy technologies. Colors represent the organization (green- Energy commission north, orange- Frisian environmental federation and purple- Province Friesland). The symbols represent the level of perceived potential (in other words: the effectiveness), the opinion and expectation of level of use in 2050 for the different technologies.

Technology	Organization	Potential of technology for Friesland.	Opinion on the technology.	Expectation of the technology in 2050
Solar panels	Energy commission north	+	+	++
	Frisian env. federation (FMF)	+	+	++
	Province Friesland	+	+	++
Windmills	Energy commission north	++	++	++
	Frisian env. federation (FMF)	++	++	++
	Province Friesland	+	+-	+
Biomass use	Energy commission north	+	+	+
	Frisian env. federation (FMF)	+	-	-
	Province Friesland	+-	+-	+-
Geothermal	Energy commission north	++	++	++
	Frisian env. federation (FMF)	+	+-	+-
	Province Friesland	++	++	++

All three stated that a mixture of the different technologies would be best for the system, but not all chose the same energy-scenario (*table 5.4-2)*. The province Friesland and the energy commission favored the geothermal scenario, because it uses the full potential of geothermal and a mixture of the three other technologies (a*ppendix 8.4.2-6 and 8.4.4-9)*. The FMF chose the fully electric scenario as the preferred scenario as the technologies used are proven effective (*appendix 8.4.3-10*).

Table 5.4-2: Preferred energy scenario.

Energy commission north	Geothermal
Frisian env. federation (FMF)	Full electric
Province Friesland	Geothermal

5.5 Biogenic model

Four interviewees were asked for their thoughts on the measures in the biogenic scenarios (table 5.4-1). The water board was only asked for peat-meadow emission reduction. Peat-meadow emission reduction was generally seen as a viable measure for reducing emissions in Friesland. The LTO was favorable for some measures in the peat-meadow area, if the farmers are compensated for costs or loss of income (*appendix 8.4.1-2 and 8.4.1-4*). The other three were favorable for extra measures in the peat-meadow area. However, the water board did not want to go as far as the measure of 95% emission reduction in peat-meadow area (*appendix 8.4.5-4*). The LTO, FMF and province Friesland were asked for their thoughts on measures in the agricultural sector. Reducing the livestock was seen as an effective measure to reduce emissions. However, the LTO was unfavorable for this measure, as it would limit the farmers in continuing their businesses (*appendix 8.4.1-6*). Most of the agricultural products are for export, yet Friesland has the GHG emissions. Therefore, the FMF argued that a reduction of livestock might be desirable (*appendix 8.4.3-8*). They were all in favor for measures in livestock emission reduction, such as new food regimes and manure treatment. Cows in barn with methane filter were received more hesitantly as a measure. The LTO was concerned for animal welfare and the image of the farming sector (*appendix 8.4.1-5*). The province Friesland was favorable in reducing fertilizer and manure, and move towards less intensive farming methods. The LTO was concerned for productivity decrease and income loss (*appendix 8.4.1-3*). Reforestation was seen as a viable measure to compensate for GHG emissions elsewhere.

Table 5.5-1: Biogenic measures. Colors represent the organization (red= Agriculture and horticulture organization north, orange- Frisian environmental federation, purple- Province Friesland and blue- Frisian water board). The symbols represent the level of perceived potential(in other words: the effectiveness), the opinion and expectation of level of use in 2050 for the different measures.

Measure	Organization	The potential of measure in Friesland.	Opinion on the measure.	The expectation of the measure in 2050
Amount lifestock reduction	Agriculture org. north (LTO)	++	-	-
	Frisian env. federation (FMF)	++	++	+
	Province Friesland	++	+	+-
Lifestock emission reduction	Agriculture org. north (LTO)	++	+	+
	Frisian env. federation (FMF)	++	+	+
	Province Friesland	+	++	+
Cows in barn and methane filters	Agriculture org. north (LTO)	+-	-	-
	Frisian env. federation (FMF)	+-	+	+-
	Province Friesland	+-	+-	+-
Reduction fertilizer and manure use	Agriculture org. north (LTO)	+	-	-
	Frisian env. federation (FMF)	++	++	+
	Province Friesland	++	++	+
Reforestation	Frisian env. federation (FMF)	+	++	+
	Province Friesland	+	+	+
Peat-meadow emission reduction	Agriculture org. north (LTO)	+	+-	+-
	Frisian env. federation (FMF)	++	++	++
	Province Friesland.	+	++	++
	Frisian water board	+	++	+-

All three integrated-scenarios are presented in the preferred integrated scenarios (*table 5.5-2*). The LTO chose the BAU scenario as it is unclear whether farmers will be compensated for income loss (*appendix 8.4.1-7*). Both the FMF and province Friesland chose the PARIS scenario as their preferred scenario. They argue that achieving the climate target is necessary (*appendix 8.4.4-9 and 8.4.3-10)*. The water board chose the PLUS scenario (*appendix 8.4.5-8*). The reasoning is that doing more to reduce emissions is desirable, but the measures in the PARIS scenario might leave the peat-meadow area unusable.

Table 5.5-2: Preferred Integrated scenario.

Agriculture org. north (LTO)	BAU
Frisian env. federation (FMF)	PARIS
Province Friesland.	PARIS
Frisian water board	PLUS

5.6 Reflection

Province Friesland has the willingness and the policies to be able to reduce all energy-related GHG emissions in 2050 (*appendix 8.4.4-2*). This means that a large reduction of energy use is necessary. On top of that, more wind mills and solar panels or other renewables have to be installed. There are large financial costs associated with these measures (Planbureau voor de Leefomgeving, 2018). Furthermore, neighbors, because of noise, drop shadow or aesthetics, often perceive renewables negatively (*Devine-Wright, 2011*). Currently a part of this potential is sought in biomass and in particular biogas from cattle manure. The potential for biogas may exist now, but in the future there may be less potential depending on the choices in reducing biogenic GHG emissions. For future policy, it is necessary to take an integrated approach to GHG emissions, so that phantom potentials are not pursued.

Option to reduce biogenic GHG emissions face technical, economic and social problems. The technical options to reduce CH_4 emissions from cows and N_2O emissions from fertilized land are limited or compromise food production. Compromising food production could be either in reducing the amount of food produced or in changing food that is produced to less GHG emitting types. New future options might make it feasible to reduce these emissions without compromising food production. A large reduction of the livestock might be necessary to curb the biogenic GHG emission in Friesland by 2050. This could have far-reaching economic effects for the province of Friesland. Without cattle, current dairy farmers in Friesland would lose their means of income. A part of the industry, such as FrieslandCampina, is also dependent on the products of the dairy farmers. It is uncertain whether a new form of economic activity would replace dairy farming. The economic implications could further current problems with depopulation and aging in Friesland. Socially, dairy farms are part of the identity of Friesland. The other measure of putting cows in a stable might make the capture of CH_4 possible, but it also limits cows in their natural behavior. Animal rights groups might not agree with such a measure.

There is also a perverse incentive to postpone reducing peat-meadow emissions or even increase peat-meadow emissions. If between now and 2050 there are high peat-meadow emissions, the total carbon pool in the peat-meadow area may be less. That might make it easier to reach the 2050 target. This perverse incentive undermines the goal of limiting the increase of global temperature.

The 95% reduction target is for the total of the Netherlands. Ultimately, it is the decision of the national government how this 95% reduction of GHG emissions is achieved. Some provinces could compensate for others by doing more themselves. Province Friesland considered this situation unlikely (*appendix 8.4.4-11*). First, all provinces face their own difficulties in the non-trivial task of reducing GHG emissions. Second, a trade in which another province virtually takes over GHG emissions for a cost, such as extra renewable energy generation may have no public support in Friesland. “More windmills so that dairy farmers can have more cows” is not a position that political parties would adopt with the current support of renewables.

5.7 Conclusions

Friesland has a major task in GHG emission reduction policy. By interviewing stakeholders, different opinions on measures, technologies and scenarios are laid out. The main conflicting opinions in energy-related emissions are the role of biomass and geothermal energy. Conflicting opinions in biogenic emissions are in most measures. All interviewees support more reforestation and better manure storage. They also support less GHG emitting livestock breeds and feed regimes.

6. DISCUSSION

The aim of this study was to investigate current and future GHG emission reduction policy. This was done by four different analyses. However, not all analyses are completely adjusted to one another. So was the sector division used in the data and policy analysis not feasible in the quantitative scenario analysis and stakeholder analysis. The two latter chapters focus more on the difference in biogenic emissions and energy-related emissions. It is imaginable to divide emissions into sectors that are uniform in either biogenic or energy-related emissions.

The data analysis mainly uses the Emission registration database. Both the Climate monitor and the first year calculation of REM have higher CO_2 emissions than Emission registration. Two explanations for these higher CO_2 emissions are the use of the IPCC standard and other attribution methods of GHG emissions to Friesland. All databases have little information on the GHG emissions of LNF. The limited literature on these GHG emissions in Friesland that is available, only portraits a part of all associated LNF emissions. The lacking emissions are non-peat-meadow LNF CO_2 emissions and the emissions from inland water. Peat-meadow emissions were considered solely CO_2 emissions, while in reality, peat-meadow emissions is a complex system with fluxes of CO_2, CH_4 and N_2O.

The model used for the scenario analysis, REM, has some limitations. Most glaring is the lack of integration of the two parts of the models. The separation is sensible as biogenic emissions and energy-related emissions are often considered independently from one another. Both types of emissions are different in source and solutions. Yet, there is interaction possible in the use of biomass. Emission reduction because of carbon sequestration and the use of biomass instead of fossil fuels are often not considered together in studies that focus on energy-related emissions or biogenic emissions alone. In REM carbon sequestration and biomass use are also not adjusted to one another. Researching this interaction more could shed more light on the viability of biomass usage for electricity production in Friesland.

Other limitations in REM are the exclusion of energy storage and overall simplicity in biogenic GHG emissions. As renewables have unreliable production patterns, large storages might be needed to pursue a high level of energy security. Biogenic CO_2 emissions of peat-meadow lands and N_2O emissions in agriculture are only represented in a single number. A greater level of detail for these biogenic emissions might show region-specific options for GHG emission reduction.

Throughout chapter two to five the focus was on the technical aspects of GHG emission reduction. Other aspects as economics, social and political aspects are only analyzed in the chapter five. Without political and public support, and without economic opportunities, new GHG emission reduction policies will not be processed. In particular the interest struggle with the agricultural sector is a large issue for Friesland. There might be more issues that are not discussed in chapter five. So is there no stakeholder for the industry in Friesland. It is likely that a stakeholder for the industry has different point of view on the energy issues than the other stakeholders included now. However, as the role of the industry in Friesland is minimal, it was not deemed necessary to include them.

7. CONCLUSIONS

This research investigated the technical and political possibilities and constraints in environmental policy for the province of Friesland. It is examined whether the policy as implemented and discussed in the outline of the Dutch Climate agreement is enough for reaching the Paris agreement GHG emission reduction targets for 2030 and 2050.

Friesland has a similar per capita GHG emissions as the whole of the Netherlands. However, the proportion GHG emissions in the agricultural sector and LNF sector are several times larger in Friesland than national. The proportion of GHG emissions in the industry sector in Friesland is only a tenth of the proportion of national GHG emissions. As CH_4 and N_2O emissions are more represented in the agricultural and LNF sector, Friesland also has a higher share of these GHG gases.

Plans for biogenic GHG emission reduction are scattered in different policy documents. These policy documents do not all relate specifically for Friesland and are generally quite vague. Most of the current GHG emission reduction policies in Friesland focus on energy-related emissions. The guideline for policy in reducing energy-related GHG emissions is trias energetica (Provincie Fryslân, 2018). First, energy use is reduced. Second, energy generation increasingly comes from renewable sources. Third, fossil fuels are used more efficiently. These three measures are found in the four sectors dealing with energy-related emissions: Agriculture, Industry, Mobility and Residential area. Overall, plans for energy-related emissions are quite elaborate.

Regional emission model (REM) is used to construct three Integrated-scenarios for GHG emissions in Friesland in 2050. In this model, energy-related GHG emissions and biogenic GHG emissions are separated. As Friesland focusses on trias energetica, for the energy-related emissions, energy use reducing technologies are implemented. The different energy-scenarios show that different technologies have minimal effects on the GHG emissions in 2030. The primary energy use does differ more among the three scenarios, with the full-electric scenario using least primary energy and the biomass-scenario using most primary energy. From the three integrated-scenarios are used to investigate biogenic emissions: business-as-usual (BAU), PLUS and PARIS; only the last reaches the GHG emissions target. The current policies and target (BAU), or doubling the targets (PLUS) achieve respectively only 77% and 83% GHG emissions reduction by 2050. Biomass provides unique opportunities in combining GHG emission reduction for both energy-related and biogenic GHG emissions. Enough biomass production for the biomass energy-scenario could be produced, but land use would be substantial.

Friesland has a major task in GHG emission reduction policy. By interviewing stakeholders, different opinions on measures, technologies and scenarios are laid out. The main conflicting opinions in energy-related emissions are the role of biomass and geothermal energy. Conflicting opinions in biogenic emissions are in most measures. All interviewees support more reforestation and better manure storage. They also support less GHG emitting livestock breeds and feed regimes.

There are many hurdles on the road to Friesland fossil fuel free and 95% less emissions. It may be tempting to stop adhering to the goals or quit with most of the climate policy all together. However, continue emitting vast quantities of GHG emissions comes with a future price. *Figure 7-1* shows how Friesland might look in 2100 if nothing would change from today.

The national Climate agreement requires regional plans for energy-generation. This research shows that national, biogenic emissions also need an elaborate plan.

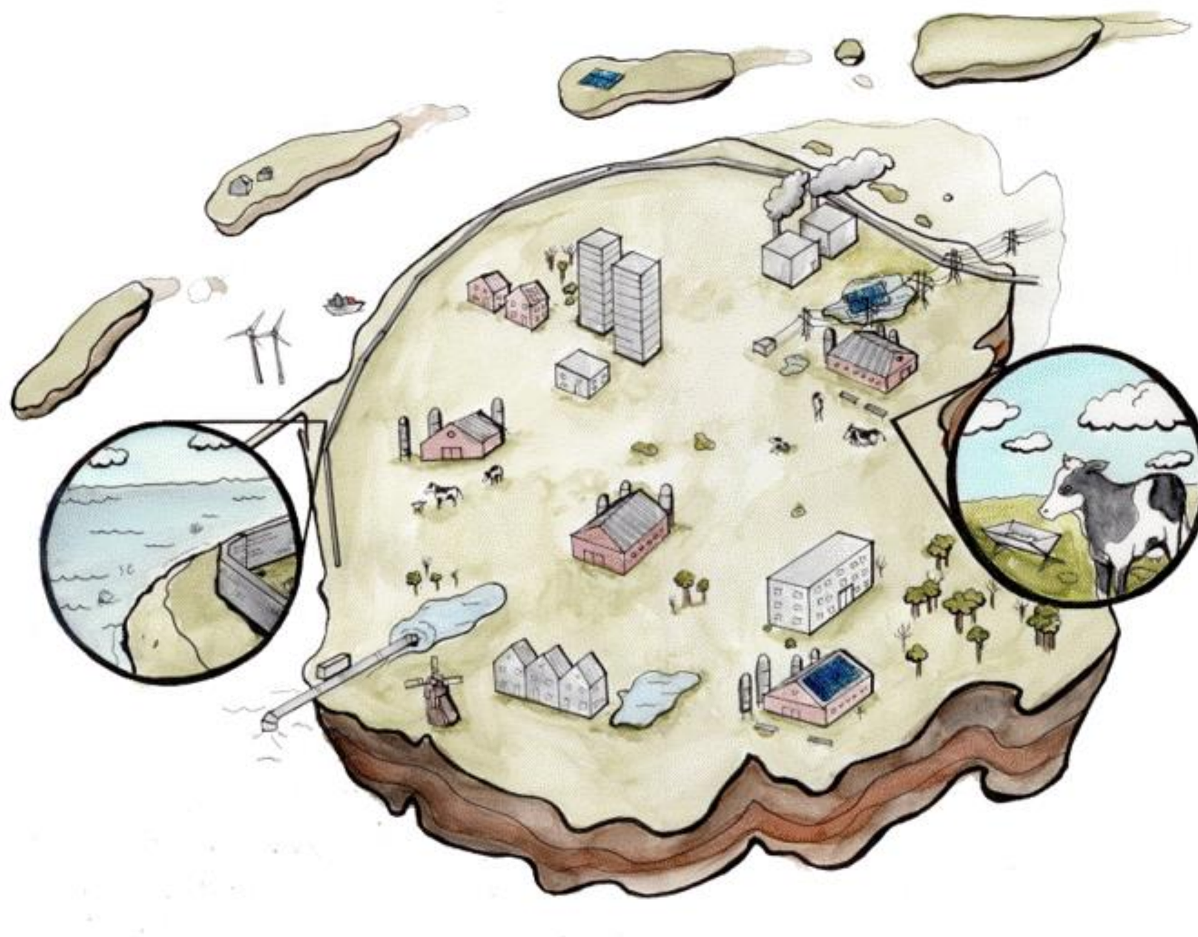


Figure 7-1: Friesland in 2100 with continuous GHG emissions. Because of the rising sea levels and ground subsidence, the dykes have to be heightened and in the northeast salinization of the soil is taking place. It may be necessary to pump up water from lake IJssel to maintain a high enough groundwater level. The cows have to be fed as production from the meadows drops.

8. APPENDIX

8.1 Current GHG emissions

Additional tables and graphs of the current GHG emissions are shown here.

8.1.1 Emissions in the Netherlands

Nationally the most important source of GHG emissions is industry (*figure 8.1-1*). Landuse is a much less important source of GHG emissions as Friesland has a relatively large part (24%) of the peat-meadow CO_2 emissions and a lower part (9%) of the carbon sequestration.

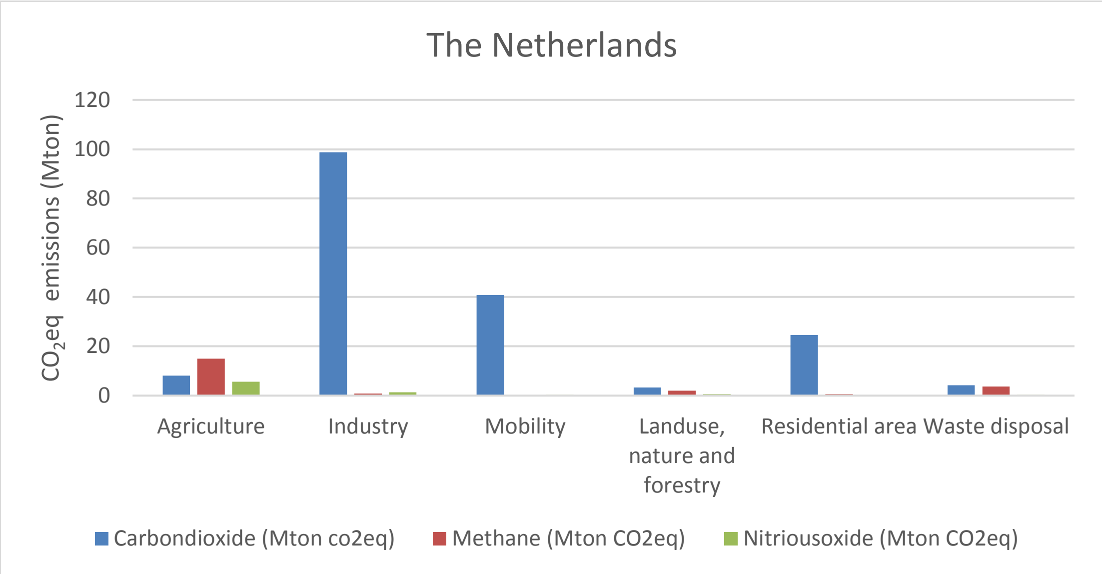


Figure 8.1.1-1: GHG emissions in the Netherlands.

8.1.2 Subsector emissions

Subsector emissions are depicted in *figure 8.1-2*. The importance of the agricultural sector is highlighted by the importance of food industry in the industry sector and to a lower degree the importance of mobile machinery (predominately agricultural machinery) in the mobility sector. GHG emissions from agriculture are mainly CH_4 emissions from cattle and N_2O emissions from livestock. In mobility, most emissions are exhaust emissions from road traffic. Landuse emissions are mainly from peat-meadow lands. Energy use (mainly heating) is responsible for the largest part of GHG emissions in the Residential area sector. For the waste disposal sector, landfill CH_4 emissions are the largest part of the emissions.

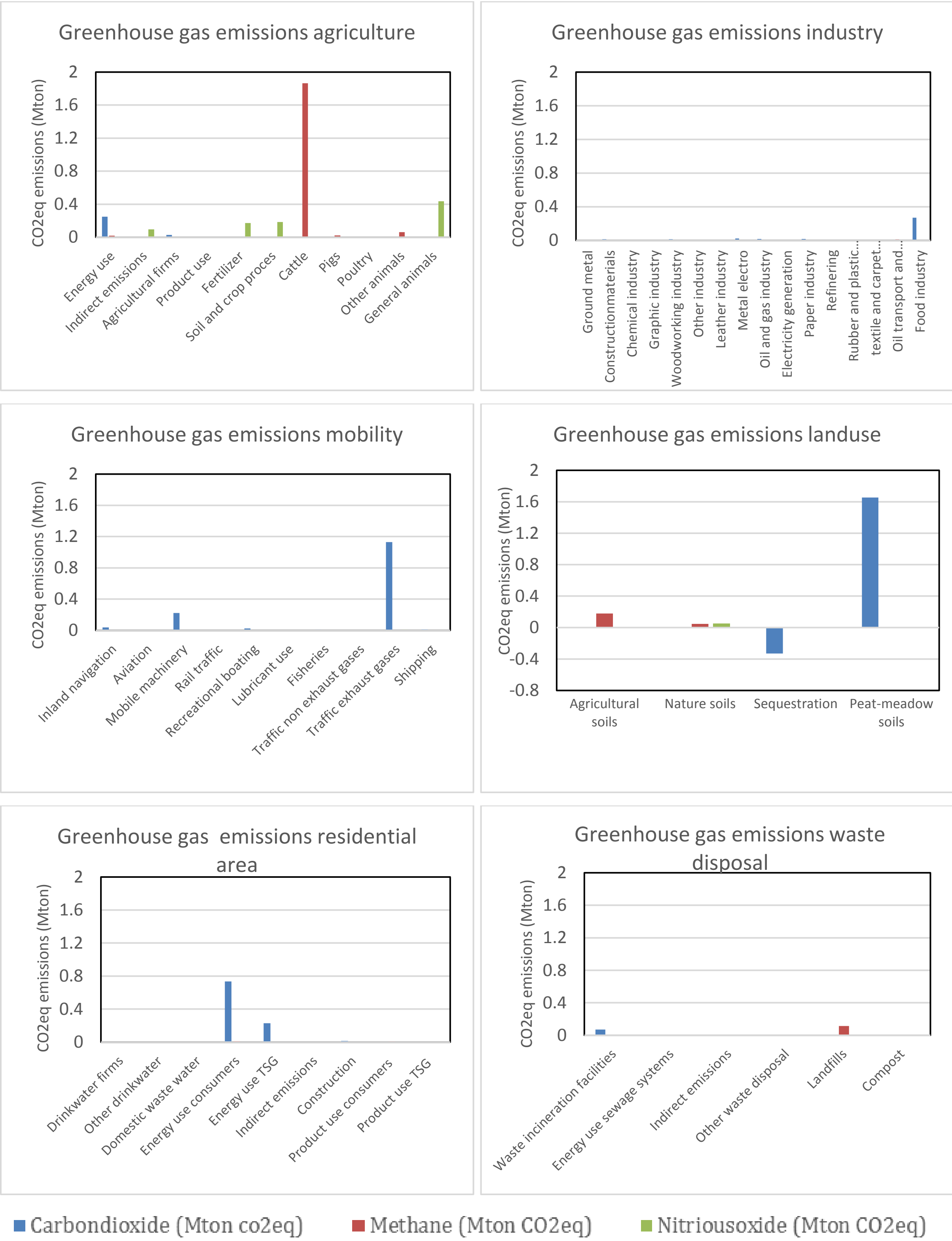


Figure 8.1.2-1: Subsector emissions in Friesland.

8.1.3 Subsector emissions larger than 0.1 Mton

Table 8.1-1 shows subsector emissions larger than 0.1 Mton CO_2eq. Together these 16 subsectors have 7.38 Mton CO_2eq of the total of 7.83 Mton CO_2eq in Friesland. This table is used to narrow down in subsectors for the policy literature review.

Table 8.1-1: Subsector emissions larger than 0.1 Mton CO_2eq in Friesland

Sector	**Subsector**	**Greenhouse gases**	**Emissions (Mton CO_2eq)**
Agriculture	Energy use	CO_2, CH_4 and N_eO	0.27
Agriculture	Indirect emissions	CO_2 and N_eO	0.10
Agriculture	Fertilizer	N_eO	0.17
Agriculture	Soil and crop proces	N_eO	0.19
Agriculture	Cattle	CH_4	1.87
Agriculture	General animals	N_eO	0.44
Industry	Food industry	CO_2, CH_4 and N_eO	0.27
Mobility	Mobile machinery	CO_2, CH_4 and N_eO	0.22
Mobility	Traffic exhaust gases	CO_2, CH_4 and N_eO	1.14
Landuse	Agricultural soils	CH_4	0.18
Landuse	Nature soils	CH_4 and N_eO	0.10
Landuse	Sequestration	CO_2	-0.33
Landuse	Peat-meadow soils	CO_2	1.65
Resi. area	Energy use consumers	CO_2, CH_4 and N_eO	0.75
Resi. area	Energy use TSG	CO_2, CH_4 and N_eO	0.23
Waste disp.	Landfills	CO_2 and CH_4	0.13

8.2 Current GHG emission reducing policies

Additional tables for the current GHG emissions reducing policies are shown here. All sector tables have the same setup. In the first column the intention for the policy is named. The second column lists the plans to achieve this intention. The third column shows the autor of the policy and the responsible government. The fourth column shows the timeframe. This third and fourth column show therefor, if the plans are worked out or not.

8.2.1 Agriculture policies

Table 8.2.1-1 shows the current policies for agriculture. Half policies are for energy-related emissions, of which have clear responsibility and currently enforced. The other policies are for biogenic emissions, and are either not clear in responsibility or timeframe. Reduce CH_4 emissions from dairy farm manure is 0.8 Mton CO_2eq and total reduction from N_2O is 0.2 Mton CO_2eq by 2030 (Klimaatakoord, 2018). Friesland has 17.3% of the cattle CH_4 emissions of the Netherlands. 17.3% of 0.8 Mton is about 0.14 Mton. Friesland has 15.8% of the N_2O emisisons of the Netherlands. 17.8% of 0.2 is 0.04. For 2050 it is assumed that this target is tripled. 0.42 Mton from cattle CH_4 and 0.12 Mton from N_2O in CO_2eq in 2050.

Table 8.2.1-1: GHG emission reducing policies concerning agriculture.

Intention	**Plan**	**Responsibility**	**Timeframe**	**Source**
Reduce energy use agricultural firms.	Enforce listed changes for firms that use more than 50.000 kwh	Provincial policy Enforced by Municipalities	Currently enforced	Provincie Fryslân, 2018
More renewable energy generation.	Using financial instruments Involve firms in local initiatives	Provincial policy Enforced by Province	Currently enforced	Provincie Fryslân, 2018
Providing information GHG emission reduction	Communicating with firms	Provincial policy Enforced by Province	Not clear	Provincie Fryslân, 2014
Reduce GHG emissions from dairy farm manure.	Changes in animals and feed. Changes in storage and manuring	National policy Enforced by ?	2030	Klimaatakkoord, 2018
National reduce GHG emissions from fossil fuel use	Using more renewable sources Using modern techniques	National policy Enforced by ?	2030	Klimaatakkoord, 2018
Climate-friendly comsumer pattern	Reduce food waste Less consumption animal protein	National policy Enforced by ?	2030	Klimaatakkoord, 2018

8.2.2 Industry policies

Table 8.2.2-1: GHG emission reducing policies concerning industry.

Intention	Plan	Responsibility	Timeframe	Source
Reduce energy use SMEs (dutch: MKB)- increase monitoring current policies	Obligations to implement energy consumption reducing changes with a cost-effectivity of 5 years or less	National policy Enforced by province and municipalities	Currently enforced	Provincie Fryslân, 2018
Reduce energy use and emissions larger firms	Using the Emissions Trading System (ETS)	European policy Enforced by state	Currently enforced	Provincie Fryslân, 2018
Reduce energy use and emissions larger firms	Using the multiyear agreement energy efficiency(MJA)	National policy Enforced by state	Currently enforced	Provincie Fryslân, 2018
Reduce energy use and emissions	Using listed technologies	National Policy Enforced by ?	2030 and 2050	Klimaatakkoord, 2018
Providing information	By projects and providing free energy use scans.	Provincial policy Enforced by province	Currently enforced	Provincie Fryslân, 2018
Using more renewable energy	Electrification	National Policy Enforced by ?	2030 and 2050	Provincie Fryslân, 2018
	Renewable heat sources			
More efficient resource use	Reuse waste products	National Policy Enforced by ?	2030 and 2050	Provincie Fryslân, 2018
	Modern recycling techniques			
	Use bio based alternatives			

8.2.3 Mobility policies

Table 8.2.3-1: GHG emission reducing policies concerning mobility.

Intention	Plan	Responsibility	Timeframe	Source
Public transport use no fossil fuel	Electrification public transport	Provincial policy Enforced by ?	2025	Provincie Fryslân, 2018
Promote electrical cars and two wheels	More charging stations	National Policy Enforced by ?	2030	Klimaatakkoord, 2018
	Financial incentives			
	Prohibit fossil fuel cars and two wheels			
Reduce emissions trucks and mobile machinery	Increase energy efficiency	National Policy Enforced by ?	2030	Klimaatakkoord, 2018
	Biofuel blends			

	Logistical optimization			
Reduce personal car usage	Promote bicycle and public transportation use	National Policy Enforced by ?	2030	Klimaatakkoord, 2018
	Promote driving more economically			
Reduce emissions infrastructure construction	Stricter requirement in tenders	National Policy Enforced by ?	2030	Klimaatakkoord, 2018

8.2.4 LNF policies

Friesland has 73,000 (about 22%) ha peat-meadow lands (Provincie Fryslân, 2015). In 2050 35,000 will be oxidized if nothing is changed. However, changes are already discussed and partly implemented. The extra measures mentioned in the both middle scenarios in this document are assumed to be implemented. Together these measures save for 4,500 ha peat-meadows from oxidation. It is unclear what the yearly emissions would be in 2050. It is also unclear what the effect of is additional measures is on the emissions. The emissions per ha will decrease with extra measure, but the total amount of ha peat-meadows might be less reduced in 2050 because of these extra measures. With the policy as implemented, the peat-meadow area would decrease by about 50%. It is assumed that the net effect of extra measures is a decrease in GHG emissions in 2050. Therefore the decrease of emissions is assumed to be 60% in 2050 with the extra measures mentioned in the veenweidevisie.

Table 8.2.3-1: GHG emission reducing concerningpolicies LNF.

Intention	Plan	Responsibility	Timeframe	Source
Reduce peat-meadow emission in non-target areas	Maximum drainage 90 cm	Provincial policy Enforced by province and municipalities	Currently examined	Provincie Fryslân, 2015
	Higher water level in summer			
	Reduce overturning of soil			
	Use underwater drainage			
Reduce peat-meadow emissions in target areas	Create new areas with higher water level	Provincial policy Enforced by province and municipalities	Currently examined	Provincie Fryslân, 2015
	Use wet crops			
	Use underwater drainage			
Reduce emissions other agricultural area	Reduce tillage	National Policy Enforced by ?	Not clear	Klimaatakkoord, 2018
	Reduce vacancy of agricultural terrain			
Reduce emissions nature areas	Enlarge carbon sequestering area	National Policy Enforced by ?	Not clear	Klimaatakkoord, 2018
	More efficient nature management product use			

8.2.5 Residential area policies

Table 8.2.5-1: GHG emission reducing policies concerningresidential area.

Intention	Plan	Responsibility	Timeframe	Source
Reduce emissions housing and community buildings	Reduce energy use	Provincial policy enforced by ?	2030 and 2050	Provincie Fryslân, 2018
	Financial instruments			
	Renewable energy generation			
Governmental buildings energy neutral	Reduce energy use	Provincial policy enforced by Province	2025	Provincie Fryslân, 2018
	Generate energy			

8.2.6 Waste disposal policies

Table 8.2.6-1: GHG emission reducing policies concerning waste disposal.

Intention	Plan	Responsibility	Timeframe	Source
Energy extraction from waste	Use waste incineration plants	National Policy enforced by state	Currently enforced	DGMI, 2017
	Waste import maximum			

8.3 Quantitative scenario analysis

Additional tables and equations of the quantitative scenario analysis are shown here.

8.3.1 Source input REM

Table 8.3.1-1: Energy part REM input

Parameter	Source
Energy use per sector	Berenschot, 2016.
Yearly population growth	Provincie Fryslân, 2017b.
Yearly growth industry and commercial	Centraal Bureau voor de Statistiek, 2018b
Yearly growth waste	Rijkswaterstaat, 2017
House age division	Centraal Bureau voor de Statistiek, 2000
Sectoral process division	Based on GHG emissions 2015.
Electricity mix	Centraal Bureau voor de Statistiek, 2018c
Biomass efficiency	Duursen et al, 2016
Fuel and technology efficiencies	Benders et al., 2011

Table 8.3.1-2: Biogenic part REM input

Parameter	Source
Food consumption	RIVM, 2014
Inhabitants Friesland	Centraal Bureau voor de Statistiek, 2018a
Initial cattle	Centraal Bureau voor de Statistiek, 2018a
Factor other animals	Centraal Bureau voor de Statistiek, 2018a
Production milk per cow	CRV, 2018
Emission fraction landfill	RIVM, 2018.
Fraction landfilled	Rijkswaterstaat, 2017
Methane emissions cow	Garnsworthy et al., 2012
Nitriousoxide emissions fertilizer	IPCC, 2006
Fertilizer use	CBS et al., 2016
Land area use Friesland	Centraal Bureau voor de Statistiek, 2018a
Reforestation	Ministerie van Economische Zaken, 2016
Other constants	Bouwman et al., 1992

8.3.2 PARIS scenario assumptions

Table 8.3.2-1: Paris scenario sources and assumptions

Measure	Source
Peat-meadow emission reduction	Estimation
Nitrious oxide emission reduction.	Estimation
Landfill methane emissions reduction	Estimation
Livestock amount reduction.	Estimation
Cattle in barn with methane filters.	Fedrizzi, et al., 2018
Cattle methane emission reduction – Breeding potential.	Garnsworthy et al., 2012
Cattle methane emission reduction – Feed regimes.	Hristov et al., 2013
Manure management emission reduction.	Groenestein et al., 2012

8.3.3 Integrated scenarios setup

Table 8.3.3-1: Integrated scenarios model setup

	BAU	PLUS	PARIS
Decrease grassland (%/yr)	0.25%/yr	0.25%/yr	5%/yr
Emissions peat-meadows 2050 (%)	40% of initial year	30% of initial year	5% of initial year
Emissions of Nitrous oxide 2050 (%)	88% of initial year	76% of initial year	40% of initial year
Animal waste methane emissions 2050 (%)	75% of initial year	50% of initial year	0% of initial year
Cow methane emissions 2050 (%)	75% of initial year	50% of initial year	25% of initial year
Landfill methane emissions 2050 (%)	10% of initial year	5% of initial year	0% of initial year
Reforestation (ha/yr)	333 ha/yr	666 ha/yr	1000 ha/yr

8.3.4 Energy scenarios output

Table 8.3.4-1: Energy scenarios results. * 2030 emissions include emissions by electricity generation elsewhere. For 2030 this is about 1 Mton CO_2eq.

	Full electric	**Biomass**	**Geothermal**
Emissions 2030* (Mton CO_2eq)	2,92 Mton	2,91 Mton	2,94 Mton
Primary energy use 2030 (PJ)	56,83 PJ	60,64 PJ	59,28 PJ
Primary energy use 2050 (PJ)	23,92 PJ	34,00 PJ	29,71 PJ
Installed wind capacity 2050 (MWp)	1141 MWp	773 MWp	815 MWp
Installed solar capacity 2050 (MWp)	2283 MWp	1546 MWp	1630 MWp
Installed biomass capacity 2050 (MWp)	0 MWp	397 MWp	210 MWp
Installed geot, capacity 2050 (MWp)	0 MWp	0 MWp	175 MWp
Fraction Friesland used biomass (%)	3,9%	28,0%	12,0%

Table 8.3.4-2: Primary energy use per sector, per fuel type. Full electric scenario 2050.

Sector	Electricity	Biomass	Total
Industry Chemicals	0.26 PJ	0.04 PJ	0.30 PJ
Industry others	4.30 PJ	0.90 PJ	5.20 PJ
Commercial	1.25 PJ	0	1.25 PJ
Waste/water	0.24 PJ	0	0.24 PJ
Farming	0.75 PJ	0	0.75 PJ
Residential existing	3.10 PJ	0	3.10 PJ
Residential new	1.65 PJ	0	1.65 PJ
Transport Passengers	5.02 PJ	0	5.02 PJ
Transport Freight	4.29 PJ	0.95 PJ	5.24 PJ

8.3.5 Integrated scenarios output

Table 8.3.5-1: Integrated scenarios results

	BAU	PLUS	PARIS
CO_2eq emissions 2030	5,29 Mton CO_2eq	5,03 Mton CO_2eq	4,27 Mton CO_2eq
CO_2 emissions 2050	0,63 Mton CO_2eq	0,46 Mton CO_2eq	-0,05 Mton CO_2eq
CH_4 emission 2050	1,05 Mton CO_2eq	0,72 Mton CO_2eq	0,16 Mton CO_2eq
N_2O emission 2050	0,58 Mton CO_2eq	0,50 Mton CO_2eq	0,28 Mton CO_2eq
CO_2eq emissions 2050	2,26 Mton CO_2eq	1,68 Mton CO_2eq	0,40 Mton CO_2eq
Reduction 2030 (%)	46%	49%	56%
Reduction 2050 (%)	77%	83%	96%

8.3.6 Biomass calculations

60 % peat-meadow area Friesland = 46,800 ha — source: Provincie Fryslân, 2015
Reforested area PARIS scenario = 30,000 ha — source: table 8.3.3-1
Dry matter production = 15,000 kg/ha — source: Duursen et al., 2016
Energy density dry matter = 19.2 MJ/kg — source: Duursen et al., 2016
Kg CO_2 per kg dry matter = 1.65 kg CO_2 /kg — source: Thomas & Martin, 2012

Equation 8.3.6-1: Biomass production if 60% of peat-meadows would be used for Typha latifolia cultivation.

$$46800 \ * 15000 * 19.2 = 13478400000 \, MJ \\ = 13.4784 \, PJ$$

Equation 8.3.6-2: Biomass production if reforested area would be used for biomass production with equal efficiencies of Typha latifolia cultivation.

$$30000 * 15000 * 19.2 = 8640000000 \, MJ \\ = 8.64 \, PJ$$

Equation 8.3.6-3: Short-cycle CO_2 emissions if 60% of peat-meadows would be used for Typha latifolia cultivation and the reforestated area would be used for biomass production with equal efficiencies of Typha latifolia cultivation

$$(46800 + 30000) * 15000 * 1.65 = 1900800000 \, kg \, CO2 \\ = 1.9008 \, Mton \, CO2$$

Table 8.3.6-1: Biomass primary energy need per scenario

Full electric	Biomass	Geothermal
1.894469 PJ	18.84635 PJ	9.399675 PJ

8.3.7 Energy security

Wind production pattern (2014) 796 MWp	source: renewables.ninja
Solar pv production pattern (2014) 2283 MWp	source: renewables.ninja
Demand pattern for 2050	source: ENTSOE, 2017
Dry matter production = 15,000 kg/ha	source: Duursen et al., 2016
Energy density dry matter = 19.2 MJ/kg	source: Duursen et al., 2016
Efficiency power plant = 45%	estimation
60 % peat-meadow area Friesland = 46,800 ha	source: Provincie Fryslân, 2015

Production is for the middle of Friesland. Demand is an estimation of the demand of The Netherlands in 2050, scaled down to Friesland. This downscaling is done by equaling the total yearly demand to the total yearly production.
The production and demand are matched on an hourly basis. The largest hourly mismatches are calculated as well as all underproductions (and overproductions) summed. Total underproduction and total overproduction are equal as the yearly production as yearly demand.

Maximum overproduction	1711.6 MW
Maximum underproduction	804.1 MW
Total underproduction	5586397000 MJ

Equation 8.3.7-1: Land area use biomass power plant 805 MWp to compensate all underproduction.

$$\frac{5586397000}{19.2 * 15000 * 45\%} = 43104.9 \text{ ha}$$

8.4 Sociopolitical assessment

Statements as authorized by interviewees are shown here (in Dutch).

8.4.1 Appendix LTO

Statement 8.4.1-1
De LTO heeft een plaats aan de klimaattafel landbouw en bijzettafel veenweide voor het klimaatakkoord.

Statement 8.4.1-2
Agrariërs hebben een rol als energieproducent, mits dat financieel uit kan

Statement 8.4.1-3
Maatregelen die emissies beperken moeten werkbaar zijn en agrariërs moeten financieel gecompenseerd worden voor verlies aan inkomsten/ extra kosten die gemaakt worden.

Statement 8.4.1-4
Extra maatregelen in het veenweidegebied zijn mogelijk, zoals grootschalige uitrol onderwater drainage en uitkopen van agrariërs die willen stoppen.

Statement 8.4.1-5
Koeien het jaar rond op stal om de methaanemissies te verminderen is niet goed voor het imago van de melkveehouderijen.

Statement 8.4.1-6
Het grootschalig reduceren van koeien is een financiele strop voor agrariërs (dus niet in het belang van agrariërs).

Statement 8.4.1-7
Het gekozen integrated-scenario is BAU

Statement 8.4.1-8
Agrariërs juichen werkbare technologische ontwikkelingen toe die broeikasgas emissies verminderen.

8.4.2 Appendix Energy commission

Statement 8.4.2-1
Ten opzichte van andere delen van Nederland heeft Friesland voordelen op het gebied van hernieuwbare energie: Friesland heeft een goed potentieel voor windenergie, biomassa en geothermie. Er is ook een redelijk goed potentieel voor zonne-energie en er is veel ruimte.

Statement 8.4.2-2
Friezen hebben een eigen mentaliteit en onafhankelijkheid. Het gevoel is: “Dit kunnen we met zijn allen wel zelf oplossen in Friesland.“

Statement 8.4.2-3
Er zijn veel lokale energiecoöperaties, zoals dorpen die energieneutraal willen worden.

Statement 8.4.2-4
Ik (lees: Bouwe de Boer) verwacht dat rond de 20% van de energie oplossing landelijk wordt geregeld.

Statement 8.4.2-5
Veel oplossingen worden lokaal geregeld zoals een windmolen, zonnepanelen, geothermie of biomassa voor een dorp, wijk of stad. Biomassa past ook echt wel bij Friesland: er zijn veel boerenbedrijven waar mee samengewerkt kan worden. Geothermie is ook ideaal, omdat de vooruitzichten onder steden goed zijn.

Statement 8.4.2-6
Het gekozen energy-scenario is geothermal.

8.4.3 Appendix FMF

Statement 8.4.3-1
Als er biomassa geïmporteerd moet worden omdat de beschikbaarheid in Friesland zelf te beperkt is, dan is dat een onwenselijke situatie.

Statement 8.4.3-2
Functies combineren is een goede oplossing om de uitstoot terug te dringen. Een voorbeeld hiervan is het waterpeil verhogen in een veenweide en daar bijvoorbeeld andere teelten toepassen of zonnepanelen plaatsen.

Statement 8.4.3-3
De FMF laat door middel van voorbeelden zien hoe het beter kan; hoe minder uitstoot kan worden bereikt. Ook proberen ze het beleid van de verschillende overheden te beïnvloeden.

Statement 8.4.3-4
Het doel is van de FMF is de 95% reductie te behalen. Nu de meest groene weg in slaan en onderweg nieuwe kansen en technologieën toepassen.

Statement 8.4.3-5
De omgeving moet betrokken worden in projecten en beleid.

Statement 8.4.3-6
Tegen alle technologieën die een impact hebben op de omgeving zal weerstand komen. Dat geldt niet alleen voor grootschalig zon of wind maar ook voor geothermie vanwege de kans op problemen in de ondergrond.

Statement 8.4.3-7
Het is vaak lastig om systeemverandering teweeg te brengen. Een voorbeeld daarvan is het valuta voor veen project, waarin agrarische ondernemers maar moeizaam meegaan met het aanpassen van de bedrijfsvoering.

Statement 8.4.3-8
Het halen van de doelstelling van 95% gaat wel ten koste van iets anders. In Friesland zal dat grotendeels landbouw zijn. Het is maar de vraag of de landbouw een uitholling van het milieu waard is, omdat veel van de landbouwproducten worden geëxporteerd naar het buitenland.

Statement 8.4.3-9
Nederland kan een gidsland op het gebied van klimaat worden als er grootschalig ingezet wordt op klimaatbeleid.

Statement 8.4.3-10
Het gekozen energy scenario is het full-electric scenario. Het gekozen integrated scenario is het PARIS scenario.

8.4.4 Appendix Province Friesland

Statement 8.4.4-1
De provincie heeft een belangrijke taak in de ruimtelijke ordening.

Statement 8.4.4-2
De provincie heeft enige ruimte in eigen beleidvoering naast het klimaatbeleid van de nationale overheid. De financiële slagkracht van de provincie is veel kleiner dan die van de nationale overheid. De provincie heeft onafhankelijkheid van fossiele brandstof als extra klimaatdoel voor 2050.

Statement 8.4.4-3
De landbouw is een belangrijke sector in Friesland.

Statement 8.4.4-4
De belangen van alle sectoren worden meegenomen.

Statement 8.4.4-5
De meeste politieke beslissingen worden genomen op basis van wat het collectief van de burgers wil.

Statement 8.4.4-6
Energie besparing heeft de focus.

Statement 8.4.4-7
Geothermie wordt een belangrijke technologie voor energieopwekking, belangrijker dan biomassa.

Statement 8.4.4-8
Zonnepanelen zijn minder omstreden dan windmolens (in de toekomst verandert dat waarschijnlijk), de provincie hecht grote waarde aan draagvlak.

Statement 8.4.4-9
Het gekozen energy scenario is het geothermie scenario. Het gekozen integrated scenario is het PARIS scenario.

Statement 8.4.4-10
De provincie ziet een enorme taak in bestrijding van broeikasgasemissies in de landbouw.

Statement 8.4.4-11
Het idee om broeikasgasemissies met andere provincies te ruilen ziet de provincie niet gebeuren. (Meer windmolens in Friesland om elektriciteit te exporteren, zodat er ook meer koeien in Friesland kunnen)

8.4.5 Statement Water board

Statement 8.4.5-1
Het beleid in het veenweidegebied is een samenspel tussen de provincie en het waterschap. De functie van het gebied wordt meer bepaald door de provincie en de uitvoering meer door het waterschap.

Statement 8.4.5-2
Het waterpeil is erg laag in Friesland en het waterschap zou graag het waterpeil verhogen.

Statement 8.4.5-3
Het waterschap staat welwillend tegenover extra maatregelen bovenop het pad dat uitgezet is in de veenweidevisie van 2015.

Statement 8.4.5-4
Het waterpeil overal in het veenweidegebied op 0 zetten ziet het Wetterskip maatschappelijk, politiek en economisch niet zitten.

Statement 8.4.5-5
Onderwaterdrainage is niet overal goed mogelijk in Friesland.

Statement 8.4.5-6
In Friesland hebben boeren een belangrijke rol in het beleid.

Statement 8.4.5-7
Het waterschap heeft als doel om in 2035 intern emissieneutraal te zijn. Voor broeikasgasemissies uit zuiveringsslib worden maatregelen genomen en voor broeikasgasemissies uit rioolwaterzuiveringen worden oplossingen gezocht.

Statement 8.4.5-8
Het gekozen integrated scenario is het PLUS scenario.

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