Energy System Economics, Modelling and Indicators for Sustainable Energy Development

T3.3 Final Project Report

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This paper presents the final report for the Netherlands team project.

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1. Introduction

In this Chapter, the Netherlands and its energy sector are introduced with a focus on European and national goals that are in place to mitigate global warming. The analysis of current trends and challenges will motivate the assessment of the impact of specific factors on the country's sustainable development.

1.1. The Netherlands

The Netherlands joined the European Union (EU) in 1999 and the Schengen area in 1995 (Government of the Netherlands, n.d.). As of November of 2022, it had a population of almost 17.8 million inhabitants (CBS, 2022), with a GDP per capita of 51.895 €, the 15th in the world (International Monetary Fund, 2022). Its economy is based on trade, being the second largest global exporter of food and agricultural products (Rintoul, 2022), as well as the chemical and metallurgy industries (Atitwa, 2018) and the energy sector. The latter is due to the fact that the Netherlands has a large share of the natural gas reserves of the EU (IOGP, 2022).

1.2. Achieving Climate Neutrality

The Netherlands is considered a natural gas, oil and coal hub; with extensive marine and terrestrial interconnections. Dutch ports are a key player in energy trade globally, thanks to large oil refining and gas liquifying terminals (IEA, 2020). Even though natural gas production has significant importance for the energy sector, its extraction has been the cause of earthquakes in the Groningen area, leading to the governmental decision of closing the wellheads in 2022 after public demonstrations and social pressure. As a result, the country is now highly dependent on fuel imports (Cole, 2021). Moreover, the country's energy consumption is dominated by fossil fuels, with a coverage of 87%, primarily due to the large chemical and refining industry, and natural gas-based heating systems. The share of renewables, relatively low for European standards, has been rapidly rising, with an increase of 275% from 2015 to 2020 (bp, 2022); the CO2 energy-related emissions, however, still account for 80% of the total Greenhouse Gas (GHG) emissions of the country (IEA, 2020a).

This high fossil fuel dependency contrasts with the urgent need for an energy transition towards climate neutrality. For this, The Netherlands is focusing on an emission reduction strategy policy, in line with the EU requirements.

1.2.1. European and National Energy Policy Goals

The Netherlands must abide by the policies and strategies of the EU towards energy transition and climate neutrality, implementing its commitments under the Paris Agreement scheme. In this context, there is one framework that stands out at a European level: the European Green Deal. Currently, it proposes a 55% reduction of emissions by 2030 (European Commission, 2022b).

To comply with it, The Netherlands has established ambitious agendas from 2019 onwards, when The Climate Act was passed. At the beginning there was a mandate to reduce emissions by 49% and 95% by 2030 and 2050, respectively; with measures and objectives by sector stated in The National Climate Agreement. However, with Europe targeting 55% by 2030, additional measures are being added throughout the years (Government of the Netherlands, 2019).

1.2.2. Climate Neutrality Challenges

There are some challenges in the emission reduction path of the Netherlands. Firstly, the four main sectors (chemical industry, metallurgy, refineries and the food industry) that drive the economy are also the ones that account for the great majority (90%) of the direct industry emissions, due to their high carbon intensity. On top of that, some of them are "hard-to-abate" sectors, which are the ones that will require the highest efforts to achieve net-zero emissions, namely shipping and agriculture, industry, aviation and buildings. Mitigation technologies that are not yet mature combined with the large upfront costs make this transition difficult. To overcome these challenges, R&D funding, regulation, and financial policies are needed (PBL Netherlands Environmental Assessment Agency, 2022).

Finally, in recent years the Dutch public opinion towards the energy transition has been shifting. A large share of the population is aiming for a more sustainable society and faster transition, which led to constant protests against natural gas production until it was announced that exploitation would stop in 2022 (Dost & Kraaijpoel, 2013). At the same time there is still some pushback, with only 45% of the population believing that more investments should be made towards renewable energies (European Investment Bank, 2021).

1.2.3. Trends

To analyse the Dutch progress towards a net-zero country, the emissions trends can be addressed. The target is to accomplish net zero by 2050. In absolute terms, by 2019 the total net emissions reached 200 Mt CO2e. Even though the Netherlands is 6% below the EU average, the total emissions decreased by only 13.4% from 2005 (Morgado Simoes, 2021). The waste management sector is the one that has reduced its emissions the most (-55%), followed by industrial processes (-33.7%), transport (-12.5%), buildings and the tertiary sector (-10.4%), the agricultural sector (-2.3%), and lastly, the construction and manufacture sector (-0.6%). Regarding the energy mix, the share of coal in the electricity generation mix must fall below 2% to avoid a temperature increase of more than 2°C. As of 2019, the Dutch average is 16%, 8 percentage points below the OECD average. In the case of renewables, the share of wind energy would need to increase to 29% from the current 9%, and the share of solar would need to increase from to 14% from the current 4% (OECD, 2021a).

Bearing this analysis in mind, it is clear that the Netherlands still faces many challenges on the path to achieve its climate neutrality goals. In this report, focus is put on the specific measures and policies implemented and a set of recommendations is proposed to help accomplish them.

2. Objectives

The main objective of the report is to inform the Extinction Rebellion's Citizens' Assembly on the social, economic and environmental implications and current status of the Netherlands' climate neutrality transition, in order to support their decision-making process towards their projects and actions.

This paper investigates the national strategies and plans that have been implemented throughout the years to accomplish the emission reduction targets of the Netherlands. These strategies span over five different sectors: built environment, industry, mobility, agriculture & land use, as well as electricity, and come along with specific goals and policies.

The three main objectives of this work are summarised as follows:

- Measure the Netherlands' progress towards climate neutrality and emission reduction goals, through national reports and models.
- Determine the appropriate indicators to analyse for each of the five sectors.
- Assess whether the current trends will allow the country to achieve its intended goals and plans.

To achieve the objectives, based on the background research performed within the five sectors, Key Performance Indicators are developed using the GENeSYS-MOD and REMES models and their scenarios to assess the trends, their similarities and differences. The results of these are then analysed in the context of the country's transition towards net zero and compared against each other. Finally, recommendations are formulated based on the conclusions reached.

3. Literature review

The background research intends to give supporting information about the Dutch energy context and how it relates to other countries at similar development stages. The indicators of sustainable development will be formulated based on the results stemming from this analysis.

3.1. Decarbonisation policies and strategies in developed countries

In the 1980s, a new element gave focus and direction to the energy security discussion: the environmental issue (Handl & Deutsch, 1972). At a **global level**, the United Nations Framework Convention on Climate Change has helped to shape the climate goals (UNFCCC, 2022a), the most relevant results being the Kyoto Protocol from 1997 and the Paris Agreement from 2015, with the objective of limiting the temperature increase to 2°C from pre-industrial levels. The UN General Assembly has also defined an agenda for sustainable development with 17 Sustainable Development Goals (SDGs) to reach by 2030 (*THE 17 GOALS | Sustainable Development*, n.d.).

In the context of the Netherlands, relevant climate goals were also defined within the **European Union**. The group of countries that make up the EU is the third largest global economic bloc in the world. While that has helped set up many ambitious agendas for reaching climate neutrality, the EU has also been dealing for a long time with a structural constraint: excessive external dependence on energy resources – natural gas, oil and coal (Eurostat, 2021).

This European exposure became more evident after the Oil Crisis of 1973, when the oligopoly of the main producing countries imposed historically high oil prices, resulting in strong instability, uncertainty and inflation (Gross & Tooze, 2022). This new scenario placed energy security and its costs at the centre of economic and political concerns for the EU.

From these and other considerations finally stems the **European Green Deal** (EGD), presented in 2019, which aims at reaching climate neutrality by 2050 by following a roadmap with concrete actions to undertake. Currently, one of the most important results of approving this action plan is setting an updated goal for emissions reduction to 55% (below the 1990 level). This has significantly influenced the national plans for reaching climate neutrality along many sectors and accelerated the process of energy transition (European Commission, 2022a).

Emerging from the EGD long-term agenda, in May 2022, the **REPowerEU Plan** was approved. It was an initiative with great economic and environmental scope, with the main goal of rapid reduction of dependence on Russian fossil fuels, due to Russia's shutdown of the Nord Stream 1 gas pipeline following invasion of Ukraine. This is planned through increasing overall energy systems efficiency, acceleration of the replacement of natural gas with clean fuels (such as green hydrogen) and increasing the market share of renewables to 45% by 2030 (from the current goal of 40%) (*REPowerEU: Affordable, Secure and Sustainable Energy for Europe*, 2022).

3.2. Economics of energy transition in developed countries

Energy transition plans are strongly related to a country’s economy. On one hand, energy-related investments are usually long-term and with significant upfront and operational costs, they make up for a large part of the overall country’s expenses. On the other hand, economics can help guide countries in following the most cost-efficient path towards climate neutrality by analysing the costs of decarbonising various sectors (Fabra & Labandeira, 2021). It is therefore important to study the effects of setting various transformation goals on the economy and energy markets.

Firstly, although the process of energy transition and investments in clean technologies is mainly perceived as a significant cost - the benefits of changing the country’s activities from high- to low-carbon intensive outweigh the costs, as research shows. This happens i.a. since the price of solar or wind power has experienced a rapid decline in recent years and energy efficiency has seen an increase. It is also worth remembering that some investments in the energy sector are unavoidable: replacing old power generating units is a necessity and investing in green energy is nowadays often the cheaper option. Moreover, if social benefits, like better health and clean air, are taken into account, the positive results of energy transition are evident (Heal, 2020).

Another factor influencing energy markets is the import of gas and oil, which both frequently experience price changes that directly translate to electricity price volatility. In the EU context, additionally, the dependence on Russian imports of these fuels was recently exposed by the consequences of the war in Ukraine, adding more concerns about the market stability. In the past, given the geographical proximity, an extensive network of gas pipelines, through which 83% of Russian gas is exported, guaranteed competitive prices for Europe in the past (Eurostat, 2021). Recently, however, the economic sanctions imposed on Russia and logistic issues with providing supply from other countries have placed the EU in the face of serious and costly energy insecurity. This overall dynamic of the natural gas market is especially affecting countries like the Netherlands, with a very high share of this fuel in their energy use.

To further incentivise the phase-out of such fossil fuels, the external results of burning them can be included in the operating costs for actors in the market; this is done through various financial mechanisms such as carbon credits or taxes. These dictate a cost for carbon emissions, making the polluting activities less profitable; although some debate is ongoing on whether a carbon tax would be more beneficial than a cap-and-trade system, they can both bring environmental benefits in terms of emission reductions in a cost-effective way (Goulder & Schein, 2013).

Apart from the mentioned factors, many others are also relevant in the analysis of the economics of the energy transition, such as financing research and development or subsidies providing incentives for the use of certain technologies. Finally, widely addressed policies and regulations, aligned with the private sector are crucial to guarantee smooth transition, minimising capital and social losses. All these aspects are also reflected in the choice of the indicators and their further analysis.

3.3. Energy Transition Key Performance Indicators

The most crucial climate goals are based on targets set to be reached by a certain year. Bearing that in mind, it is important to also establish which quantitative measures or Key Performance Indicators (KPIs) can help assess the process of energy transition and whether the aforementioned goals can be expected to be achieved. The KPIs can either be horizontal, meaning that they can be used for the entire economy, or sectoral, regarding a specific part of the economy (Velten et al., 2021).

The Measuring Progress Towards Climate Neutrality report (Velten et al., 2021) lists five important horizontal KPIs:

- **Net zero transition finance** - assessing the sustainability of various investments by public and private entities.
- **Enabling technologies** - focusing on investments in R&D and progress of technologies that will help achieve set climate goals.
- **Lifestyle changes** - measuring the effect of behaviour changes in the society and its impact on climate action.
- **Just transition** - ensuring that all parts of the society are equal on the path to net zero.
- **Governance and political support** - analysing the impacts of regulatory changes on the actions undertaken in all sectors.

As the report also states, a proper choice of KPIs is a difficult task, since the progress towards net zero varies largely between single countries, but also specific economic sectors. At the same time, these indicators should provide a holistic overview of the decarbonisation progress, therefore the sectoral indicators for the Netherlands are also studied in the following section.

3.4. Netherlands context

Since the Paris Agreement in 2015 and in line with the European Green Deal, the Dutch public and private sectors are taking aligned action plans to invest in clean approaches to reach the sustainable development targets, according to the Dutch Integrated National Energy and Climate Plan 2021-2030 (NECP), which focuses on energy policies for the next 10 years (The Ministry of Economic Affairs and Climate Policy, 2019).

The actions behind the country’s emission reduction goals are focused on five main sectors. The most relevant topics of the country’s strategy are given below, based on NECP:

- **Built environment:** increasing the energy efficiency of buildings and decreasing the share of natural gas in space heating.
- **Industry:** lowering the emissions by increased use of renewables, carbon capture and storage as well as hydrogen, promotion of circular economy.

- **Mobility:** reduction of car and increase of shared transport use, shift towards electric and hydrogen propulsion systems.
- **Agriculture and Land Use:** decrease the agricultural land use and increase of forest and nature area, reduction of emissions from livestock and food waste.
- **Electricity:** utilising the full potential of renewable energy sources in the country, increasing the electrification rate of the economy.

More detailed information regarding specific sectoral goals, measures to reach them, as well as current state and related Key Performance Indicators can be found in *Annex A*. The indicators chosen for the purpose of this project are developed within these five sectors, as well as from the whole country's perspective.

3.4.1. Stakeholder Involvement

The Netherlands sought broad public support in the elaboration and implementation of their Climate Agreement as the government acknowledges the critical role of community in a successful transition. Citizens contributed to the Climate Agreement through local town halls and online events by proposing plans, ideas, and underlining their concerns. Additionally, more than a hundred stakeholders, including organisations and businesses likely to have an impact in enabling the transition, were convened to discuss sectoral themes such as labour market & education, spatial integration, finance and innovation (The Ministry of Economic Affairs and Climate Policy, 2019). Developers, funding agencies and authorities participated in mobilising all social groups in the country regarding their expected contributions to the transition and monitored public perspectives in the formulation and adoption of climate policies.

Following the discussions, Regional Energy Strategies (RES) comprising renewable electricity generation, heat for buildings, storage and energy infrastructure were put forth at the regional level. The regions individually designed mechanisms to involve their local communities, such as access to information, independent process guidance and economic support. Regarding the Gas-free Districts Programme, for example, that assesses the necessity to use central boilers for heating, a district-oriented approach under municipalities' direction was adopted. The best solution varies by district socio-cultural profiles and encourages learning and association from diverse stakeholders. The government also ensures that market parties and the environment weigh in on the feasibility of large-scale energy projects. By 2030, the goal is to create locally owned energy generation projects (50%) (The Ministry of Economic Affairs and Climate Policy, 2019). The stakeholders will supervise the construction and operation of these, to help boost their social acceptability and guarantee their sustainability.

Through the designed KPIs and recommendations formulated in this report, the Citizens' Assembly alongside the government, businesses, and funding agencies will be well equipped to weigh in on Netherlands' current climate initiatives. Furthermore, this report will motivate the stakeholders to support informed decision-making on the aforementioned sectoral themes, reinforcing the existing involvement of local communities.

4. Methodology and case study

In this Chapter the methodology of creating the indicators for the study is presented, preceded by a description of the models and scenarios used for the analysis. The following information was obtained from Auer, H., Crespo del Granado, P., Oei, PY. et al. (2020) for GENeSYS-MOD and Werner, A.S., Pérez-Valdés, G.A., Johansen, U., & Stokka, A. (2017) for REMES.

4.1. Tools and scenarios used

The online platform chosen to assess the development of the indicators was the OpenEntrance project, published in the IIASA Scenario Explorer, where a combination of variables and scenarios can be used to understand the trends of different factors of the Netherlands context.

4.2. Models behind the scenarios

The first model used is **GENeSYS-MOD** (Global Energy System Model), which is a linear program that minimises total system costs. Energy demands are predefined and the model needs to provide the necessary capacities to meet them. To achieve a cost-optimal energy mix, the model considers different technology options, including generation, sector coupling, and storage. A regional update has been conducted from initially 17 European countries to 30 so data collection and disaggregation have been made for the new countries. A much more disaggregated representation of the demand sector, specially in the industry sector has been implemented.

To study the effects on the social context the **REMES** model was used. This is a multi-regional, multi-sectoral Computable General Equilibrium model analysing the impact of various climate policy measures and the interaction between national and regional energy markets and the overall economy. Since the REMES model contains regional details for various real economic variables, it allows to see the interrelations between the energy system and the labour and housing market.

4.3. Scenarios used for the analysis

In the openENTRANCE project four different scenarios were created to describe different development paths of a low-carbon European energy system. In each of them the characterisation emphasises the most salient key drivers, the renewable penetration is high and there are different grades of demand side participation of individuals and communities. The scenarios are interpreted in the context of the existing analysis of a global emission reduction path that has the goal to limit global warming below 2°C. To build the scenarios, three individual drivers have been found to represent the societal, technological and policy dimensions: "smart society" that maximises engagement and awareness of the society to take concrete actions to tackle climate change; "technology innovation" centred around technological breakthrough; "policy exertion", representing a world where effective policy measures successfully steer the energy transition.

The four scenarios considered are:

- **Societal Commitment**

  This scenario assumes a high societal engagement and awareness of the importance of reducing emissions. Individuals, communities and the overall public aim to support policies accelerating the energy transition. Top-down and bottom-up governmental-led approaches drive behavioural changes in energy usage and citizen choices, so that “green” initiatives are followed to decarbonize the energy and transport sector. This scenario underlies the hypothesis that there is a lack of major achievements in technological development.

- **Techno-Friendly**

  In this scenario, the deployment of new technologies and changes in behavioural energy choices leads towards lowering greenhouse gas emissions. This is achieved with little resistance to adopting new technologies and openness to large-scale infrastructure projects, even though centralised decision-making and policy steering are difficult to reach, so the driver of this scenario comes from grassroots initiatives and industry taking action to deliver novel technology.

- **Directed Transition**

  In this scenario, strong policy incentives are required to uptake and develop carbon-mitigating energy technologies. It is assumed that the effect of grassroots and citizen-led initiatives will be minimal but that the needed engagement of citizens will be driven by strong policy incentives in order to reach the climate target. There is a strong centralised vision on the part of policymakers and a direct partnership with industry and technology developers who respond to incentives provided by the public sector providing advantages in low-carbon energy-related technologies.

- **Gradual Development**

  The last scenario supposes that the climate target of 2°C is reached through an equal part of societal, industry/technology and policy action. This storyline combines parts of each of the previously described scenarios and so represents an ambitious scenario in openENTRANCE.

Within these scenarios, 10 indicators were developed, as outlined in the next section.

4.4. Development of the indicators

Following the overview, a detailed methodology for creating the indicators is presented. All these were created using output variables from the simulations in openENTRANCE.

I. Share of carbon-free sources in the national energy mix

Bearing in mind the large dependency of the Netherlands' energy system on fossil fuels (see section 1.2), it is deemed important to study the share of carbon-free sources in the generation of electricity. In order to do so, the projected generation capacity from clean energy sources is set against the overall generation capacity for electricity production. Biomass production is excluded from this analysis, since the overall lifecycle is not considered and the feedstock is not replanted fast enough, meaning its use may lead to an increase in emissions; nuclear power is considered despite the fact it is non-renewable, since the energy generation process is emission-free.

II. Relation between emissions per capita and GDP per capita

In the Netherlands' climate strategy, the foremost target aims at the reduction of greenhouse gas emissions. However, when crafting national plans and adopting measures to combat climate change, the government seeks not to impede the economic growth of the country. Consequently, assessing emissions of CO2 per capita versus GDP per capita until 2050 stands as a significant indicator that helps to understand how the country has managed to transition toward a more sustainable future while also succeeding in increasing the well-being of its citizens.

III. Carbon Market

Since The Netherlands is part of the European Carbon market it is relevant to analyse an indicator that tracks the correlation between the development of the carbon prices and the emissions' reduction. In order to do so, two variables from openENTRANCE results were combined: (1) carbon price and (2) annual emissions. Then they have been multiplied for every year of available data in order to understand the yearly market value of carbon emissions.

IV. Share of electricity in the final energy supply

It is known that the electrification of the final demand in the different sectors is beneficial towards climate neutrality given that non-carbon emitting sources can be easily used to produce this needed energy (Tchung-Ming et al., 2020). Therefore, this indicator analyses the growth rate of electrification in the final energy supply. The data considers multiple sectors such as transport, buildings and industry.

V. Electrification of the heating system

This indicator was developed to show the electricity penetration in the decarbonization process of the heating sector. This has been done by dividing the installed electric heat capacity, such as heat pumps, by the total heat capacity for heat in the residential and commercial sectors.

VI. Hydrogen use in the heat demand of the industry

The Dutch industry is based on high temperature industrial processes with high carbon intensity, that are presently supplied by natural gas, as seen in Chapter 1.2.2. Taking this into consideration, the shift to a more sustainable fuel is an important aspect to study in the climate transition context. In this case, hydrogen would play a key role in the transition towards a sustainable industrial production (Neuwirth et al., 2021). For this reason, it seems important to study the share of heat provided by hydrogen in the industry compared to the total heat needed in the industry throughout the coming years.

VII. Share of battery EVs in total number of EVs for passenger transportation

Since the Dutch government provides large subsidies to the electric vehicle industry (see *Annex A*), it is assumed that EVs in private passenger transportation will largely increase in the future, replacing traditional cars propelled by internal combustion engines. There are also ambitious plans to increase the production of hydrogen; however, the use of batteries is currently more feasible than the use of fuel cells (especially for smaller vehicles and individual passenger transportation). Hence, the share of battery-powered cars in total EVs is evaluated as an indicator of properly addressed goals for the transportation development.

VIII. Labour Price Index

The labour price index was selected as an indicator in order to understand how the energy transition would impact the labour market. The index is compared to 2010 levels and extracted from the REMES model. It represents the cost of labour on the market and how it evolves over time, which pertinently supports social good supervision.

IX. Electricity Price Index

On the REMES model it is possible to see different product price indexes that reflect how commodities will change in price from 2010 to 2050. The electricity price index has been selected because it directly impacts the livelihood of people and industry and is also a major driver of inflation as we have seen recently. Hence, understanding how this will evolve can help the policymakers to provide adequate responses.

X. Agricultural Products Value

As highlighted in Chapter 3, The Netherlands are one of the biggest exporters of agricultural products even if they make up a minor part of their GDP and job market since it is a developed country. Nonetheless it was important to see if and how the transition could impact this sector. From the REMES model it has been chosen as the indicator “agricultural product output” that shows the values of the output of this sector during time.

5. Results and discussion

In this Chapter, the quantitative results of the developed indicators are presented followed by a discussion of these in the context of the Dutch economy's pathway towards net zero goals.

5.1. Results

The quantitative results of the computed indicators are presented below for all four scenarios.

I. Share of carbon-free sources in the national energy mix

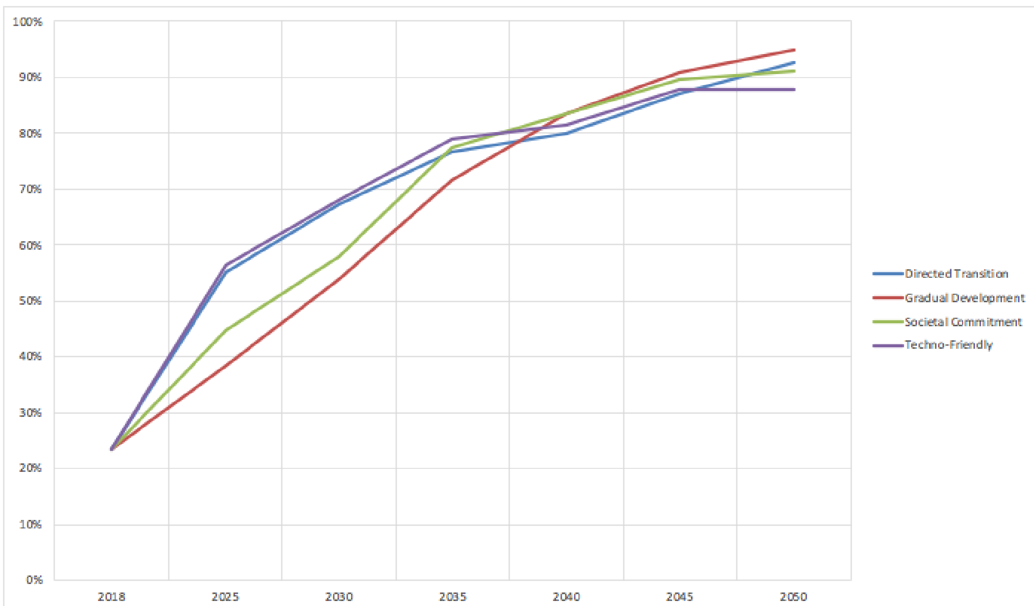

Figure 1. Percentage share of carbon-free sources in the energy mix.

According to all the considered scenarios, the share of carbon-free energy sources in the electricity generation will be gradually increasing. As can be seen in *Figure 1*, for all the scenarios the final share of clean energy sources reaches a value of around 90% in 2050.

Although for all scenarios the final share of carbon-free energy sources is high, there does remain some natural gas capacity which is decreasing over time (refer to *Annex B*). Nevertheless, it is worth remembering that the policy towards various fuels has changed fairly recently, mostly resulting from the war in Ukraine. Therefore, it is expected that shares of coal-based generation will increase due to the fact that the Dutch government has lifted the cap to coal power generation that was established at 35% in 2021, setting back the renewable transition (GlobalData, 2022), but gaining independence from natural gas. Thus, with the system missing this "transition fuel", potentially more capacity of renewables would be necessary. On top of that, two new units of nuclear power have been announced calling off the nuclear phase out plan as well (World Nuclear Association, 2022). This may result in lowering the required additional capacity for renewable energy sources, since nuclear power provides a stable baseload supply.

II. Relation between emissions and GDP per capita

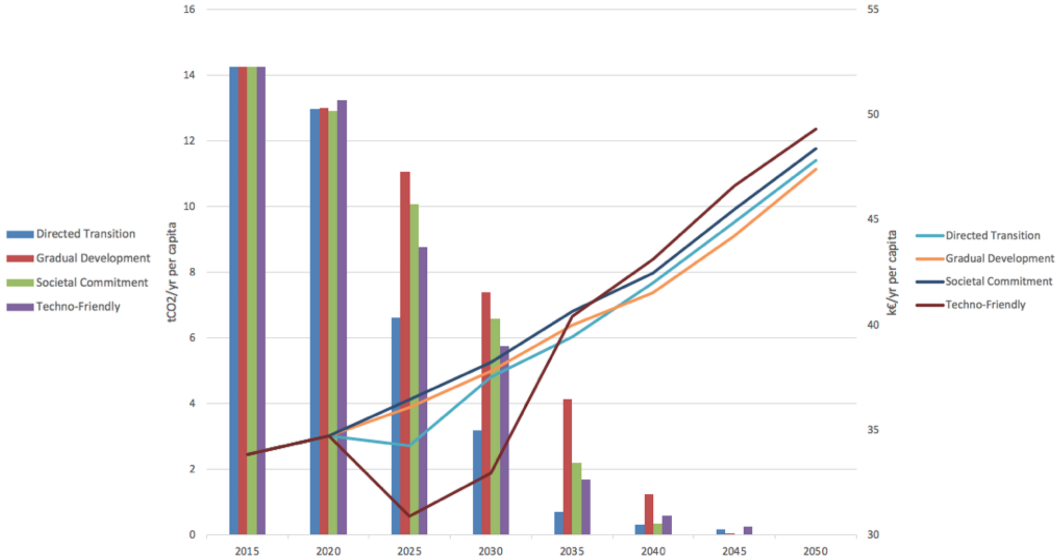

Figure 2. Relation between emissions per capita and GDP per capita.

All the scenarios considered project a gradual decline in CO2 emitted per capita until 2045 and even negative emissions around 2050. That transition to clean energy resources can be seen as the natural consequence of the measures adopted by the Netherlands as outlined in its national strategic plans (interim target of -49% in 2030 and -95% by 2050 in comparison to the 1990 level). On the other hand, the GDP per capita grows steadily over the years. Several factors including industrial innovations resulting from the energy transition can help explain that trend. Rather than impeding the Netherlands' economic growth, the mechanisms leading to the reduction of CO2 emissions might even boost the GDP per capita.

This moves in line with what the Environmental Kuznets Curve (EKC), a function with an inverted U shape, implies: economic growth is the main solution against pollution. This model is the most followed approach by economics to study this matter (Stern, 2018), as it presents the transition of economies from clean agrarian or pre-industrial to then a polluting industrial framework, finally centering growth on clean services.

At first, with the rapid increase in development, resources are consumed faster than generated, increasing waste and emissions, but at a certain point structural changes, regulations, technology development and environmental awareness result in a peak point where the tendency starts to decrease (Dinda, 2004). In the Netherlands, this peak occurred already around the final years of the 1990 decade, since then a slight decrease has been observed (Our World in Data based on the Global Carbon Project, 2020) and, taking into consideration the results shown in *Figure 2*, the decreasing tendency will continue throughout any scenario.

III. Carbon Market

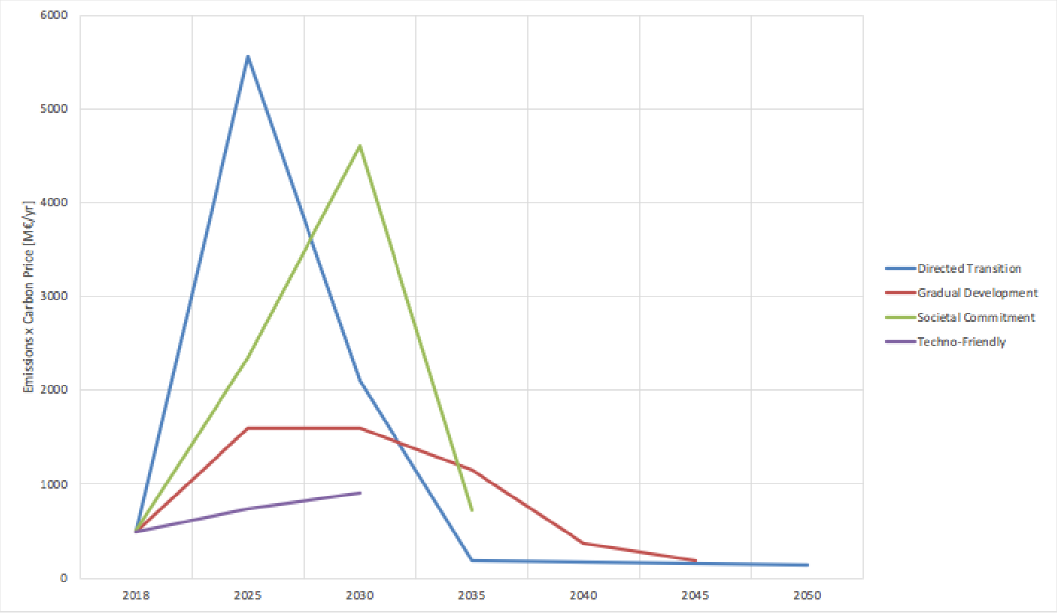

Figure 3. Carbon market.

Figure 3 illustrates that the carbon emissions market value grows until the period limited by 2025 and 2030, depending on the scenario. After that, it presents a strong decrease until 2035. This downfall must be a consequence of lower carbon emissions, considering that carbon prices are constantly increasing (refer to *Annex C*). This can be explained by the distribution of carbon credits that consists in creating an artificial scarcity of carbon as an asset to increase its price. Therefore, it is expected that the price demotivates emitting carbon practices. Nonetheless, it is difficult to quantify to what extent the emissions' reduction is a consequence of the carbon price increase, considering it must also be related to other causes.

It is important to mention that the Netherlands introduced a carbon tax in 2021 to induce a faster climate transition. This tax sets a minimum price for the cases when the EU ETS system trading price is lower. However, the EU market has been registering prices above 80 €/ton which largely surpasses the 60 €/ton tax price expected for 2024 by the Dutch government.

If EU ETS prices keep increasing and the carbon tax is maintained above it, Dutch companies will need to transition faster and with higher costs, which might lead to a decrease in international competitiveness. This could happen especially in sectors like the heavy industry, where emission reduction is not as easy, and absorbing this carbon cost while investing in development and innovation may be a struggle, thus affecting the future economy (The Sustainable Finance Platform, 2022).

IV. Share of electricity in the final energy supply

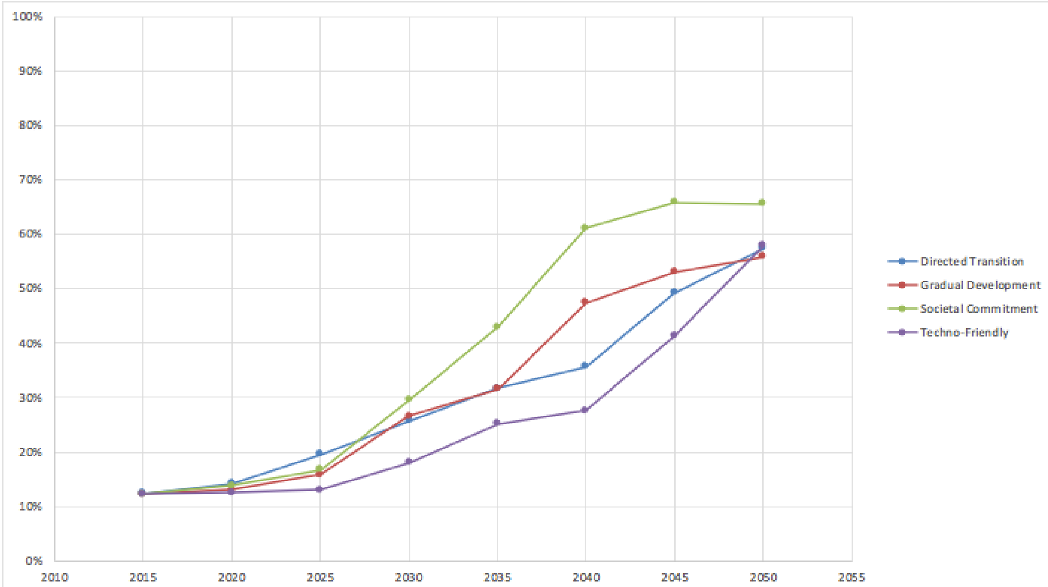

Figure 4. Percentage of total electricity consumption in the total energy supply.

The general electrification rates (*Figure 4*) have an increasing trend in all scenarios, reaching around 55-65% by 2050. It is relevant to note that the *Societal Commitment* presents an earlier accelerated increase, since 2025, and reaches considerably higher results than the other scenarios. This could be explained due to higher environmental awareness by society, therefore being more inclined to change private appliances and their transportations methods.

When looking at the specific graphs of each sector (refer to *Annex D*) the following conclusions can be derived. Firstly, for the transport electrification, all scenarios, except the *Techno-Friendly*, show a peak of only 30% in 2035, whereas the latter gets up to 77%, even if there are more than 100,000 semi-public stations (Nederland elektrisch, 2022) as well as EV subsidies for the population (Government of the Netherlands, 2022a) indicating that the quality of the infrastructure is very high. However, electric maritime and air transportation are still sectors in early stages of development. Only in a context where research and openness for the deployment of big projects is a priority, these sectors could take off as fast as the *Techno-Friendly* scenario predicts.

Secondly, the residential and commercial sectors have a high share of electrification, specially for the *Directed Transition* scenario where it reaches more than 75% by 2050. For this to be the case, a large deployment of heat pumps will be needed. This is already taking place in the Netherlands, with policies and subsidies to replace gas boilers with heat pumps, in new constructions and when substitution is needed from 2026 onwards (Netherlands Enterprise Agency, 2022a).

Finally, in the industry sector, electrification takes off in 2025 for all the scenarios except for *Techno-Friendly*, where this occurs in 2040. In the Netherlands there is already a plan set in place to boost industrial electrification, starting by adding new renewable capacity (up to 46 GW by

2050), enhancing the electricity and hydrogen transmission infrastructure and making sure there is enough technically qualified personnel that exchanges knowledge between companies and organisations. If the plan is accomplished, 60% of the industry needs will be met by electricity by 2050 (Institute for Sustainable Process Technology, 2021), which goes in line with what is predicted by the scenarios.

All in all, it is important to remark that the electrification towards reducing climate impact will only result in emissions reductions if supported by renewable energy, thus having a low carbon intensity of the generation capacity, which relates to Indicator I.

V. Electrification of the heating system

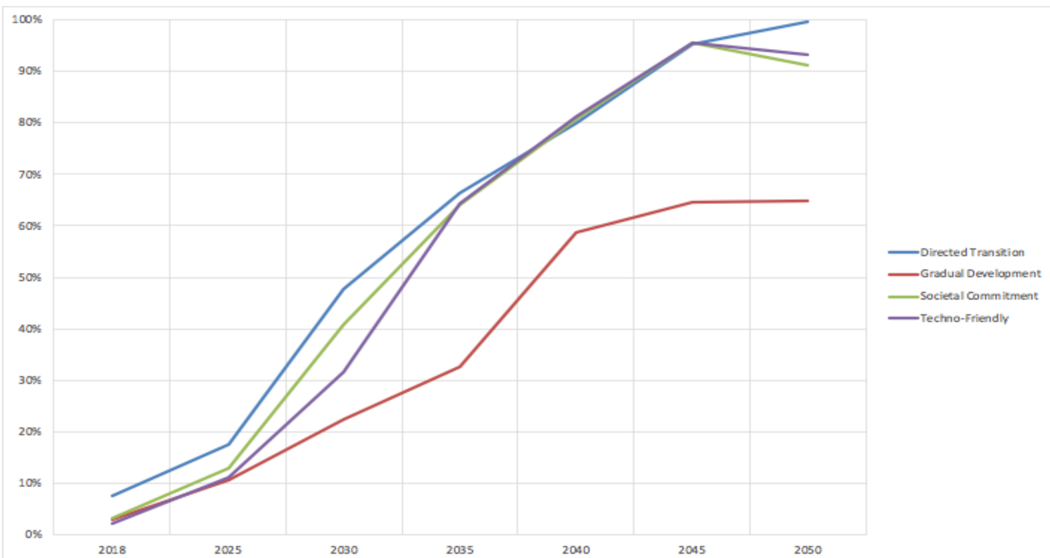

Figure 5. Percentage of heating demand covered by electricity.

All the scenarios seem to have a quite similar trajectory in the development of electrification for the residential and commercial sector. We can see in *Figure 5* that only the *Gradual Development* scenario lags behind but it is a coherent result compared with its hypothesis. The electrification of the heating sector will decrease the share of heat produced with fossil fuels and consequently reduce the emissions directly associated with heating. This will also be followed by a reduction in the total demand for heating due to technological progress, efficiency increase and behavioural changes. The newly installed capacity is supposed to be coming mainly from wind power hence the electrification will reduce emissions. Nonetheless, it can be seen from the results of openENTRANCE that the capital cost for electricity in the heating sector is an order of magnitude higher than the capital cost for gas-fueled heating (refer to *Annex E*), meaning that subsidies must be given to achieve the desired goal of electrification without leading to an increase in energy poverty.

As seen in the previous indicator analysis, the Netherlands will ban any fossil fuel-centric heating systems in households by 2026, and will make the installation of heat pumps or the connection to district heating mandatory (Netherlands Enterprise Agency, 2022a), while giving subsidies of a total of more than €150 million every year until 2030 to support this transition (Kurmayer & de Jonge, 2022).

VI. Hydrogen use in the heat demand of the industry

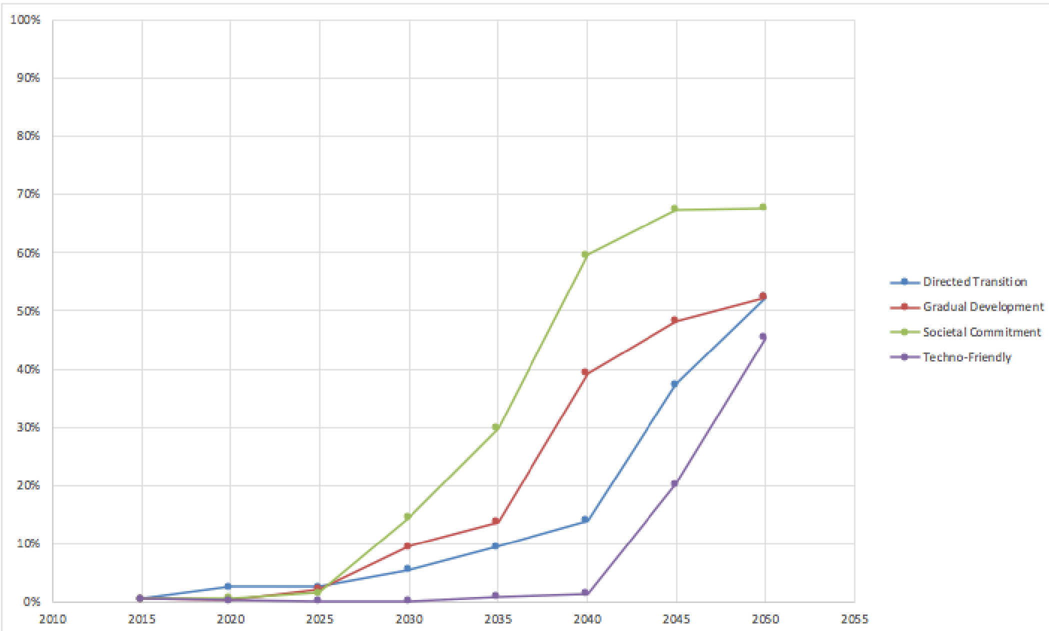

Figure 6. Share of hydrogen use for heat purposes in the Industry.

It can be seen in *Figure 6* that, for all the scenarios, the share of hydrogen in meeting the heat demand in industry is higher than 40%, reaching even 70% in the *Societal Commitment* scenario. The real deployment would start in 2025 under all the projections except for *Techno-Friendly* where it starts in 2040, suggesting that policy support will likely favour a development of hydrogen usage in the industry sector.

Currently, only Germany exceeds the Netherlands in the EU in terms of hydrogen consumption and grey hydrogen dominates the Dutch market. The Article 22a of the Renewable Energy Directive (RED) mandates that the contribution of green hydrogen should be 50% of the total hydrogen used for "final energy and non-energy purposes in industry by 2030" in the EU member states (CE Delft, 2022). Even though failure to comply with this directive does not incur any penalties (as of now), it is expected to be translated into national law by 2024. The implementation of this policy will corroborate the projection seen in *Figure 6*. Further investigations into hydrogen use in the Netherlands have shown that up 38 to 61 TWh of renewable electricity generated via electrolyser and offshore wind capacities (9~14 GW) is required to meet the 50% target (CE Delft, 2022).

VII. Share of battery EVs in total number of EVs for passenger transportation

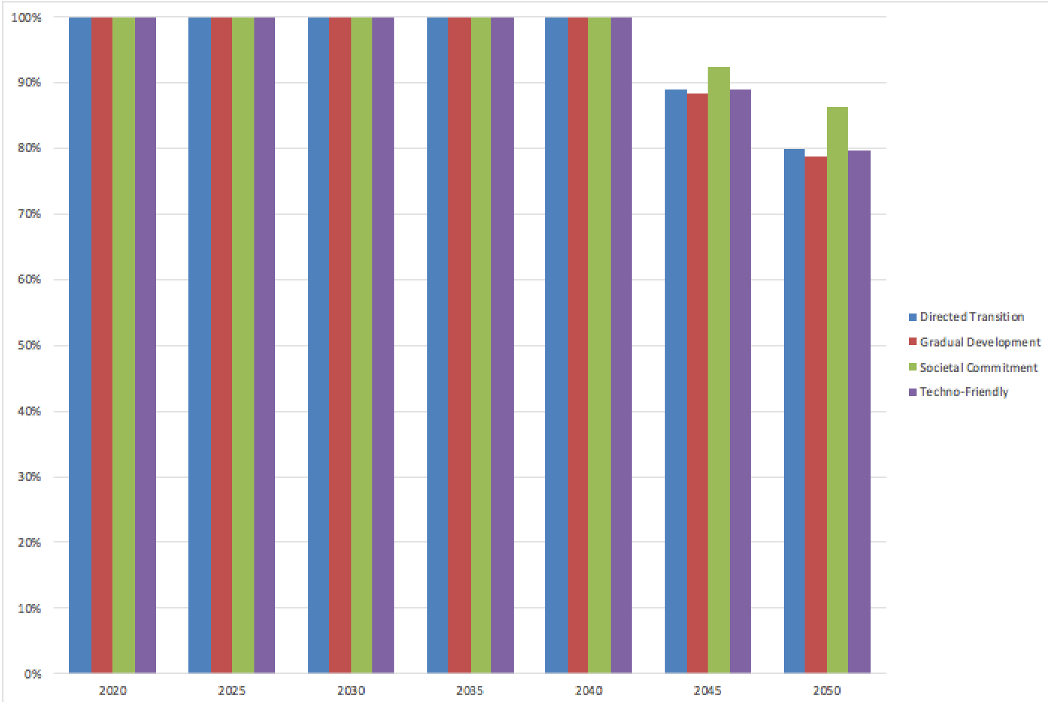

Figure 7. Percentage of battery EVs in total number of EVs.

From the graph in *Figure 7* it is clearly seen that at least until the year 2040 there are no predictions of the use of fuel cells in passenger transportation. This is aligned with expectations, as the use of batteries for EVs is currently much more feasible than hydrogen, which is more crucial in the decarbonisation of other sectors, such as high temperature industrial processes.

The Netherlands already has one of the most robust EV charging infrastructures in Europe (Nederland Elektrisch, 2022) and the purchase of battery-powered vehicles is subsidised (Government of the Netherlands, 2022a). As of December 2022, there are only 15 hydrogen refuelling stations (HRS) (Frey, 2022), although a national hydrogen transport network is planned to be developed by 2031, with an investment of €750 million (Rogers, 2022). Moreover, from 2024 onwards, subsidies incentivising the installation of new HRSs are planned, to grow the hydrogen-powered trucks fleet (FuelCellsWorks, 2022). These plans clearly explain the tendencies shown in *Figure 7*, with the hydrogen transportation framework developing years after the battery one.

An additional conclusion stemming from this analysis is that the number of Gpkm (giga passenger kilometres) per year decreases 7-fold from 2015 to 2050 (refer to *Annex F*). This indicates that for all the scenarios consumer behaviour changes and increased use of public transportation are projected. The Netherlands has a plan to enhance this trend with a vision towards 2040 and onwards, which includes measures such as offering fast and high frequency public transportation connections between the four major cities in the country and other densely populated areas.

Moreover, in suburban areas smart mobility will be implemented, enhancing car sharing or e-bike services. All of this will be topped with real-time smart applications to advise travellers with the best public transport routes to their destinations (Ministry of Infrastructure and Water Management, 2019).

VIII. Labour Price Index

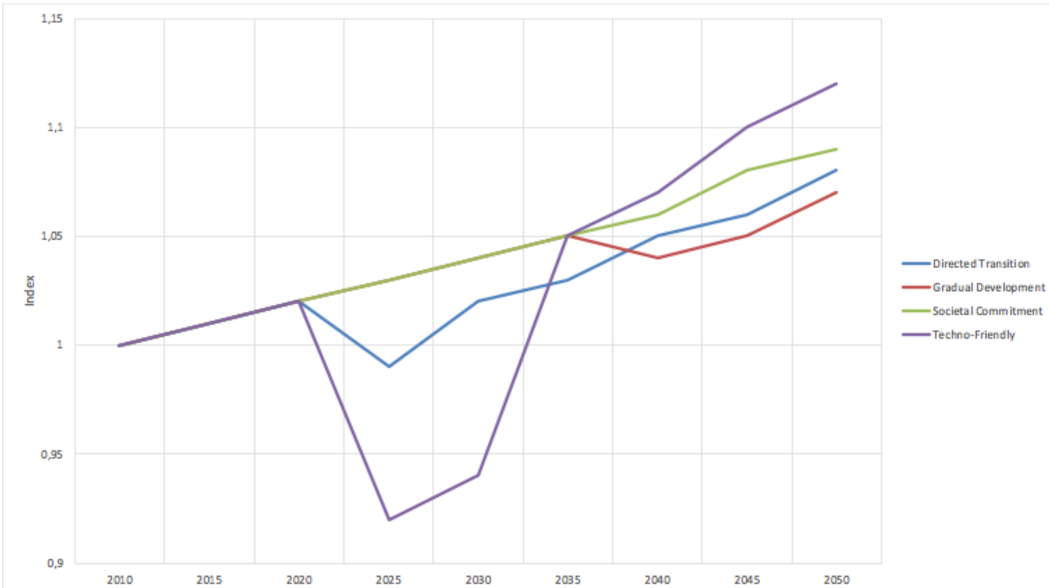

Figure 8. Labour Price Index.

Figure 8 shows that the cost of labour increases in all scenarios compared to 2010 levels. It can be seen that the increase is not drastic considering the time frame and also taking into account the inflation during the period. Therefore, it is relevant to mention that the increase of the cost of labour is not supposed to be seen as a sign that the employment rate will decrease. On another note, it is interesting to observe that the *Techno-Friendly* scenario foresees that in the first years there is a drastic fall in the cost of labour which then recovers and reaches the highest increase between the scenarios. Due to the introduction of new technologies and the consequent increase in productivity, the cost of labour may decrease in the short term, due to an oversupply of workforce. In the long-term though, this leads to a work time reduction and a consequent increase in the labour cost (Dachs, 2018), as it can be seen in *Figure 8*. The same can be said for the *Gradual Development* scenario, but with a lower intensity due to the fact that the evolution is smoother. In this sense it is important to understand this phenomena to avoid increases in unemployment.

When looking into the data, as of 2022, the Netherlands is the fourth highest country in Europe in terms of minimum gross wage (Eurostat, 2022), which for 21-year-old and older workers is 1,756.20 € a month (Government of the Netherlands, 2022b). However, this value is adjusted every six months, and the government has already announced a 10.15% increase by the 1st of January of 2023 (Netherlands Enterprise Agency, 2022b). Therefore, the tendency is to keep increasing salaries with time, which matches the trend seen in *Figure 8*. On top of this, the direct employer costs, which are direct contributions to the social security system, are averaged at around 23.23% in the country, however they are capped for salaries above 59,706 € a year which could be considered a benefit for external companies wanting to expand within the country (Eurodev, 2022).

IX. Electricity Price Index

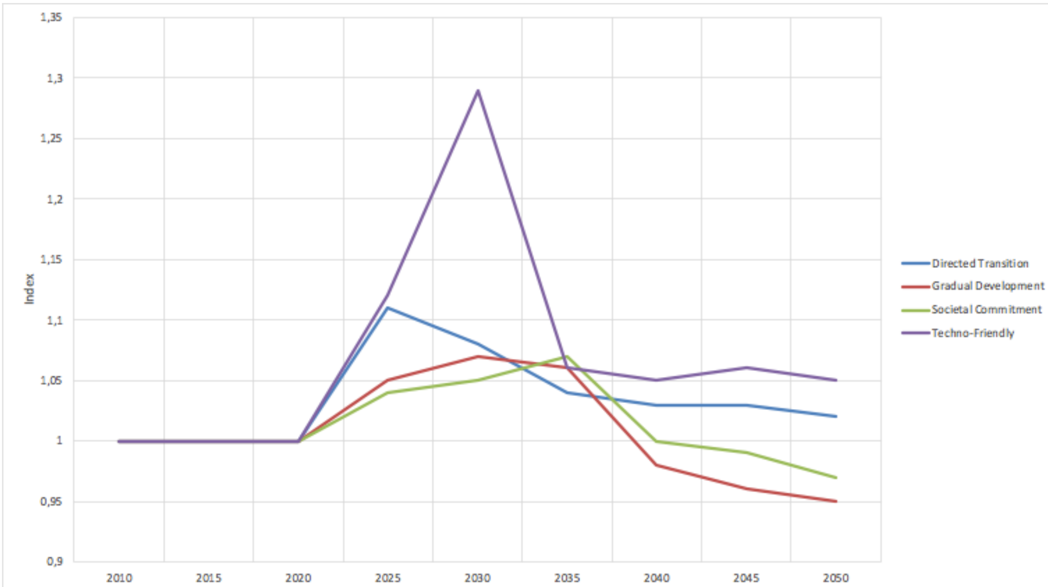

Figure 9. Electricity Price Index.

All the scenarios forecast an increase in the short term of the price of electricity, as can be observed in *Figure 9*. This is problematic especially in the *Techno-Friendly* scenario where we can see an increase of almost 30% compared to the current price. This could lead to a serious phenomenon of energy poverty for the less affluent part of the population, which has to be avoided in order to prevent negative consequences of the energy transition. Following the increasing electrification of different sectors, an increase in electricity price could result in indirect effects such as an increased cost for the electric bus operator that will result in an increased ticket for consumers. The *Directed Transition* scenario highlights a similar pattern but reduced in intensity due to the different hypothesis. Both scenarios are characterised by a focus on industry and this could lead to a lower degree of engagement by individuals that would not change their behaviours if compared to the required efforts.

Due to the current energy crisis the Dutch government has established a cap on the electricity prices of 0,40€/kWh (Government of the Netherlands, 2022c). Measures like this may have to become the norm if the price of electricity rises too much. It must also be mentioned that the European electricity markets are already interconnected, having the German and French markets as a central core with Austrian and Dutch markets acting as periphery (Bosco et al., 2010), so a spike in price in The Netherlands could lead to increases in price in the neighbouring countries leading to extended consequences.

Another important point to highlight is that the speed of the transition must not be excessive to avoid shocks such as the ones that the *Techno-Friendly* scenario could cause. In the long term it can be seen that all scenarios show electricity cost decrease, with the *Societal Commitment* and "Gradual Development" that reach even lower values than current ones. This emphasises the fact that even if in these scenarios the decarbonisation process will be longer, they can achieve similar results to the others in 2050, while avoiding economic shocks in the meantime.

X. Agricultural Products Value

Figure 10. Agricultural Products Value.

Figure 10 shows that an increase in the absolute value of the agricultural products in the long term is expected, following a short decrease in the beginning of the transition. The *Techno-Friendly* scenario achieves a higher value in the long term thanks to the investments in new technologies that can boost productivity due to the spillover effect (O'Mahony & Vecchi, 2009). Based on these results it can be argued that the agricultural sector will benefit from the transition.

The Netherlands is today the second exporter of agricultural products in terms of value worldwide, thanks to cutting-edge technology such as vertical farming, seed technology and robotics. The great majority of the crops grow in greenhouses hence needing less fertiliser and water (Reiley, 2022). Greenhouses need energy though, so it must be considered that the price has to remain low; otherwise this could compromise the technical innovation and efficiency of the sector. This indicator confirms this trend and predicts that due to the new increased value of exports, more effort towards the sustainability of agricultural sectors could be made. To deploy innovation and sustainability in the agricultural sector, a strong push from the institutional characters is needed and the relationship with the European and international dimension must be taken into account (Veldkamp et al., 2009).

5.2 Discussion

The ten indicators selected in this study span across three dimensions: social, economic and environmental - as expected by the Extinction Rebellion's Citizens' Assembly. Even though they provide a broad overview of the Netherlands' context and help motivate the report's recommendations, the range of options is restricted by the availability of data in the openENTRANCE database. Specifically, social indicators, such as generation of employment due to the transition, impacts on Dutch citizens' life expectancy or climate-change-induced migration were discarded due to lack of relevant data, although they could have generated valuable insights for the Citizens Assembly and interested stakeholders.

The assumptions used in the models, while creating well-defined boundaries to facilitate the interpretation of the results, also define the limitations of the study. Firstly, apart from the three drivers (smart society, technology innovation and policy exertion) underpinning the evaluated scenarios, the models do not account for the existence of alternative development pathways. Therefore, the results mentioned above only depict a set of predictions among many others that could be valid. Secondly, it is relevant to mention that the available models do not incorporate other plausible drivers and it can be argued that it is highly unlikely that the transition in any country will follow the polished rationale proposed. Thus, models including issues such as public acceptance and technical challenges – known as "delayed action on climate mitigation" – or the non-inclusion of specific technologies in long-term climate mitigation possibilities – known as "fragmented approaches to mitigation" (Krey, 2014) – could provide additional insights closer to reality. Thirdly, critics point out that existing energy scenarios tend to overestimate the likelihood of a future somewhat similar to the recent past (Paltsev, 2016). This implies that the uncertainties regarding future costs and the resulting technologies in the energy mix are significant. It is therefore suggested that stakeholders should view the results of such studies as a qualitative analysis on possible pathways and strive to encourage the development of all energy sources instead of emphasising on the handful predicted via the scenarios (Paltsev, 2016). Nevertheless, the scenario results as detailed previously show that on the policy, economic and environmental levels, the Netherlands are on the right track to reach the targets set in their Climate Agreement.

The results related to electrification – indicators *IV*, *V* and *VII* – all suggest that there will be an increase in demand for electricity. Hence, the Dutch electricity market needs to be increasing its provision for clean sources, which is directly related to progressive results of indicator *I*. It is relevant to mention that the trend of the results in indicators *IV* and *VI* will not conflict with each other in the industry sector. While the first is taking into account transport, buildings and industry total energy, the latter considers only the heat demand for industrial processes. Between indicators *IV* and *V*, it can be highlighted that the "Electrification of heat" is a zoomed in slice of "Electrification share of the final energy supply" since they are both considering electricity share in the final energy supply. Furthermore, indicators *II* and *VIII* illustrate aligned results. As carbon emissions decrease, it is expected to see a more developed technological industry over time. Consequently, the economic environment will flourish, which is manifested through a higher GDP per capita and stabilised labour index growth rate, but it has to be noted that in the *Techno-Friendly* scenario in the indicator *II* there is a decrease in GDP which is reflected in the decrease of the labour index around 2025.

The projections from indicator *X* can be related to indicator *II* as agriculture accounts for approximately 14% of the country's total emissions (van Grinsven et al., 2019). One can expect that if agriculture value increases, GDP also increases, but it is relevant to know that the GDP share of agriculture is around 1.5% in the country (*Agriculture, Forestry, and Fishing, Value Added (% of GDP) - Netherlands | Data*, 2022). Technological development will enable the growth of agricultural productivity resulting in creating more economic value with less carbon emissions.

Regarding indicator *IX*, it is of importance to notice the high increase (2020-2035) then followed by a decrease (2035-2050) in electricity prices shown by the *Techno-Friendly* scenario. It may be the consequence of a strong dependence on electricity generation from expensive sources (e.g. natural gas) during the first years of the forecast, while after a certain point the developed renewable technologies start to play a bigger role in the energy mix, leading to the price decrease. It could also be linked to the considerable increase in the share of electricity in the total energy supply – indicator *IV*. It could be argued that a significant increase in electricity demand will lead to higher prices of electricity.

Additionally, it is worth highlighting some converging and contrasting trends among the scenarios evaluated. The *Techno-Friendly* scenario projects the quickest achievement of climate goals, but is also more likely to generate social shocks (reflected by, for example, the electricity price index indicator). Similarly, high carbon taxes implemented in the *Directed Transition* scenario result in the most rapid emission decline in the early years. The *Societal Commitment* scenario performs better than *Techno-Friendly* on the electrification of transportation, suggesting that the Dutch government must bet on citizens' behavioural change rather than investing massively on new mobility technologies.

6. Conclusions

This project's main objective is to deliver value to the Extinction Rebellion's Citizens' Assembly, related to sustainability and decarbonization in the Netherlands. The work investigates strategies, policies, regulations and trends that can shed light on the future of the country within this scope. To carry out this analysis, a study was initially done over the main historical facts that brought The Netherlands to its current path towards climate neutrality, as well as relevant recent events that influence it. Following this, the openENTRANCE tool was used, which allowed access to projections of different parameters in four given scenarios. The data was then crossed to suggest relevant indicators that can contribute to the understanding of potential consequences and future effects for the country on its journey to a net-zero reality.

According to the observed results, this paper makes the following suggestions for the Citizens' Assembly:

1. Support policymakers to create legislation towards supporting social behavioural changes. It includes for example subsidies to homeowners that invest in net-zero technologies in their houses and transportation.
2. Ensure there is a balance between encouraging the society to actively participate in the energy transition and the development of relevant infrastructure, for example building enough EV charging stations in cities to enable an effortless change from conventionally propelled vehicles to electric ones.
3. Support regulation actions regarding fossil fuel taxation, but always accounting for the financial health of the private sector to protect not only environmental aspects but also economic and social ones, for example by avoiding a large increase of electricity prices for end users.
4. Beware of reliability when communicating energy sector-related topics in the media, since there is a lot of conflict of interest among market participants. For example, when discussing hydrogen inclusion in the energy transition, emphasis should be put on the alternative technologies in each use case, to assess if there exists a more appropriate solution.
5. Invest time and effort in educating society about nuclear power generation to guarantee a proper understanding towards its risks and benefits, considering the problematic existing misinterpretation on these.

As can be concluded based on the indicator results, the *Societal Commitment* scenario can achieve very good results, hence the main suggestion for the Extinction Rebellion’s Citizens’ Assembly is to engage the population in activities to spread the knowledge of actions that can be undertaken by the citizens to tackle climate change, as the society may have a significant impact on many of the analysed aspects of the journey to net zero.

Through the analysis of the 10 indicators, it can be said that the Netherlands' are on track to reach the stated climate neutrality and emission reduction goals. While for some of the developed indicators the results are similar for all the scenarios, in others the path chosen and policies applied can significantly influence the result in the final year, or the dynamics of the transition. Therefore it is important to perform relevant simulations for all the suggested changes to ensure all stakeholders' interest is taken into consideration and the climate goals are successfully achieved

Future work regarding this topic could be focused on assessment of other indicators that are not present in this paper. Furthermore, a multi-criteria analysis could be performed to evaluate the interests of each stakeholder in order to fully understand the outcome of the policies to be implemented or modified to reach these goals.

Overall, the analysis of the Netherlands' journey from setting the climate goals to developing plans to achieve them has allowed to obtain a holistic overview of the measures the country can use, as well as the important role the Extinction Rebellion's Citizens' Assembly has to play in the country's energy transition.

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Annexes

Annex A - Sectoral Goals and Measures

Table A.1 Sectoral goals and measures within the Dutch National Climate Plan (The Ministry of Economic Affairs and Climate Policy, 2019) and other documents.

Built environment	**Goals:** Increasing the energy efficiency of buildings, limiting the use of fossil fuels while making a shift to more environment-friendly heating solutions for 8+ million buildings by 2050. **Current state:** Central heating boilers are widely used and a substantial part of the heating demand is met by natural gas. **Measures to reach goals:** The Netherlands is aiming for a transition at the district level in which the government will support homeowners via subsidies or loans and information campaigns on building retrofitting standards. Additionally, their national plans outline programmes whose goal is to facilitate investments in large scale sustainability enhancement of the entire building sector. An example is encouraging cooperative solar and wind energy projects, where users are the ones who organise themselves to produce energy and sell it to the grid. **Related Key Performance Indicators:** (IEA, 2020b) ● Percentage of reduction of natural gas heating in buildings. ● Percentage of public and commercial buildings natural gas free. ● Share of building energy consumption covered by renewables. ● Percentage of retrofitted buildings**.**
Industry	**Goals:** Reach a climate-neutral industry sector by 2050 (*Integrated National Energy and Climate Plan*, 2020). **Current state:** Industry is responsible for 26.6% of total emissions (*OECD*, 2019) Energy savings measures and major action plans in the use of biomass are being taken (*Integrated National Energy and Climate Plan*, 2020) **Measures to reach goals:** Investments on renewable sources. Government policies to reduce taxes towards renewables and offer subsidies. Collaboration with other like-minded European countries. Joint development of CCU/CCS ("Carbon Capture and Utilisation/Carbon Capture and Storage") and green hydrogen (*Integrated National Energy and Climate Plan*, 2020). Government programs for the circular economy growth and incentivisation. **Related Key Performance Indicators:** ● Renewables share of energy supply (*Integrated National Energy and Climate Plan*, 2020). ● GHG emissions share of industry sector [tCO2 /kwh] (Ecologic Institute & IDDRI, 2020). ● Government policies versus increase in use of renewables. ● Year-by-year energy savings (*Integrated National Energy and Climate Plan*, 2020).

	● Electricity prices for industry in EU, globally and The Netherlands [EUR/MWh] (Ecologic Institute & IDDRI, 2020). ● Energy consumption in industry per amount of investments in circular economy [kWh/EUR value added] (Ecologic Institute & IDDRI, 2020). ● Low carbon cost divided by conventional processes cost [%] (Ecologic Institute & IDDRI, 2020).
Mobility	**Goals:** Regarding mobility, the main goals of the outlined national plans comprise the reduction of car use by enhancing the attractiveness of alternative modes of transport, as well as shifting towards electric and hydrogen transportation. **Current state:** The country presents a very powerful transportation sector, including examples such as the Port of Rotterdam which is the largest seaport in Europe (Van Den Bosch et al., 2011) and the Amsterdam Airport Schiphol, ranking 5th in traffic in the world (Dugdale, 2018). **Measures to reach goals:** Netherlands intends to reinforce the availability of emission-free energy sources for mobility (charging infrastructure for EVs, subsidies for hydrogen production, advanced biofuels & renewable synthetic fuels). The government also plans to roll out innovative programmes to stimulate behavioural change, digitalisation of EVs and improvement of battery technologies. **Related Key Performance Indicators:** ● Expenditure per capita on transport. ● Share of low-emission fuels. ● No. of electric charging points.
Agriculture and Land Use	**Goals:** The main goal is to decrease the share of agricultural land use and increase forest and nature share, while shifting into a more circular approach. **Current state:** The Netherlands is an international leader in agriculture, especially for its commitment to research and technology, which has allowed an outstanding production performance. Nevertheless, the sector is responsible for a large share of the country's emissions, caused not only by CO2 but also methane and nitrous oxide. **Measures to reach goals:** Reducing emissions in livestock farming. Emission reduction and CO2 storage through smart land use. Food consumption and food waste. Making greenhouse horticulture more sustainable. **Related Key Performance Indicators:** ● Diet carbon footprint. ● Food waste per capita. ● Share of agricultural land with organic farming. ● Average carbon sequestration in top soil layer.

Electricity	**Goals:** Create a climate-neutral electricity generation system. Increase the share of renewable sources, limit the dependency on fossil-fuels, especially natural gas. **Current state:** Nowadays the Netherlands' electricity generation is strongly dependent on gas and unfortunately, due to the energy crisis happening as a consequence of the Russian conflicts, the country has returned to the era of burning coal. In June of 2022 the Dutch Climate and Energy Ministry announced that the country would withdraw its production limitations for coal-fired power plants from 2022 to 2024 due to the increased risks of gas shortages (*Cabinet Takes Energy Security Measures | News Item*, 2022). According to some sources, in 2021 the government also decided to abandon the previous plans of nuclear phaseout and build two additional nuclear power plants (*Nuclear Power in the Netherlands | Dutch Nuclear Energy | Holland Nuclear Power*, 2022), although there are no official plans regarding this matter on the Government's website (*Nuclear Energy | Renewable Energy*, n.d.). **Measures to reach goals:** To reach the set goals, the country has to use the full potential of renewable generation, for example by investing in offshore wind farms or domestic solar power. **Related Key Performance Indicators:** ● Share of renewables in generation of electricity. ● Carbon intensity of electricity generation. ● Carbon emissions that are captured and stored. ● Electrification rate of the economy.

Annex B - Natural Gas Electricity Capacity

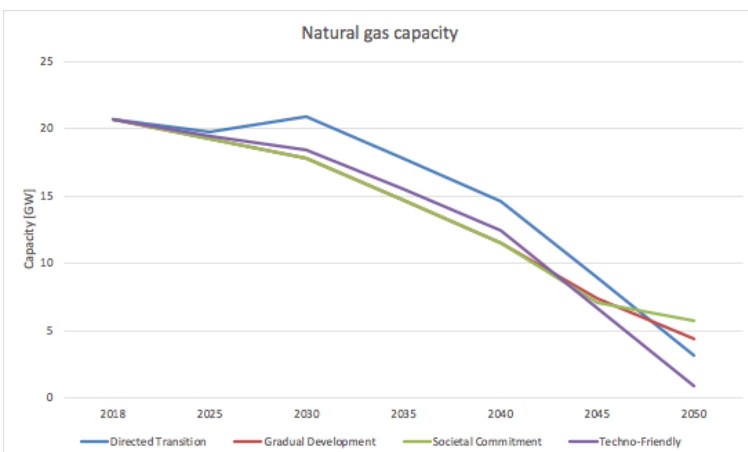

Figure B.1.Natural gas capacity.

Annex C - Carbon Price

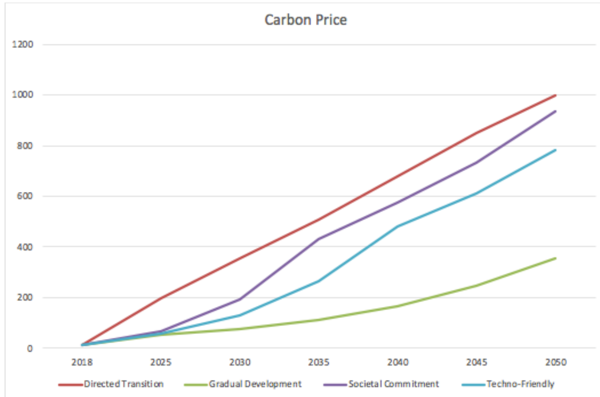

Figure C.1. Carbon Price.

Annex D - Electrification of different economy sectors

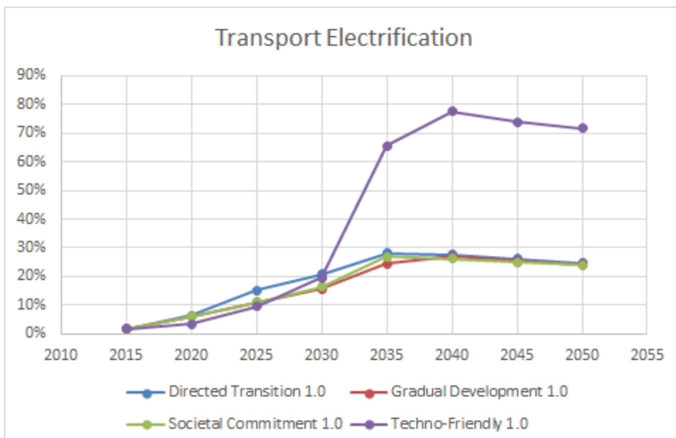

Figure D.1. Transport Electrification.

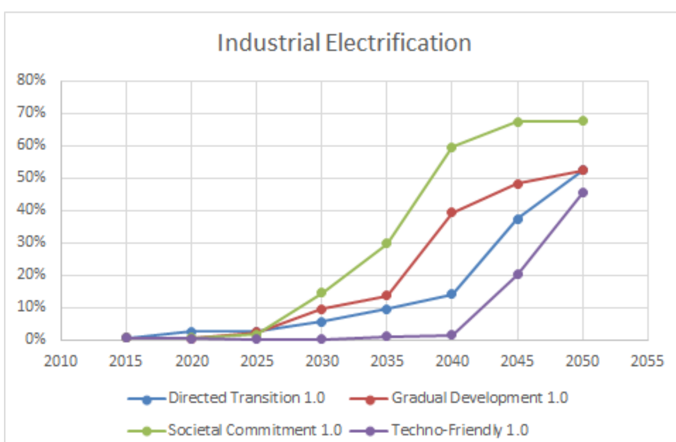

Figure D.2. Industrial Electrification.

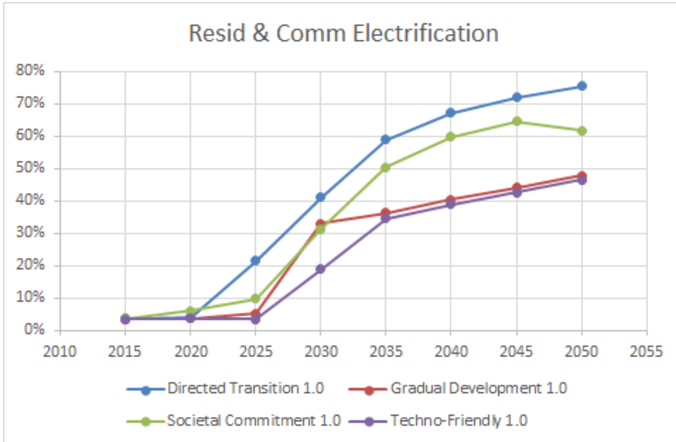

Figure D.3. Residential and Commercial Electrification.

Annex E - Heating Capital Cost

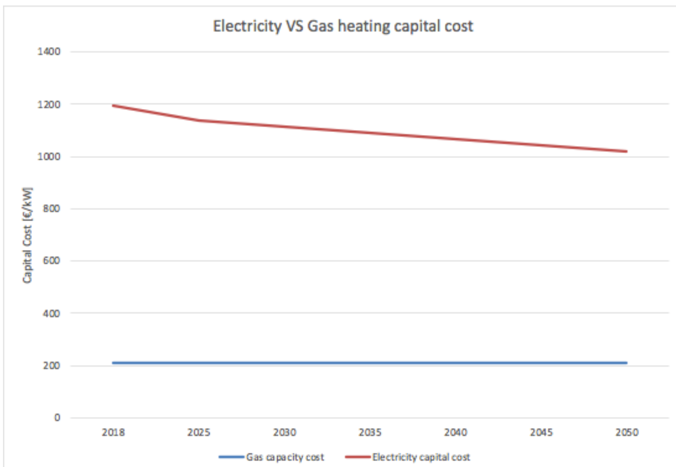

Figure E.1. Carbon Price.

Annex F - Giga passenger kilometre (Gpkm) change

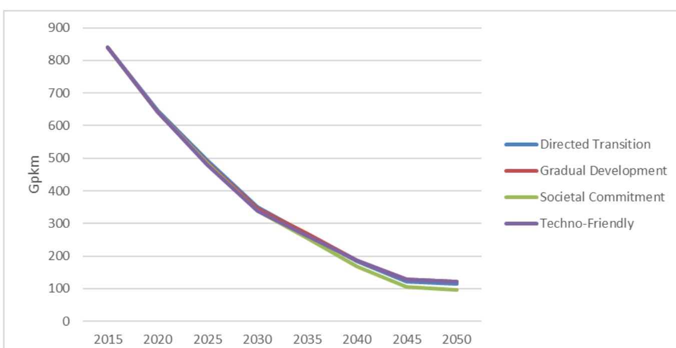

Figure F.1. Gpkm changes in various scenarios.