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Publication date
2020

Document Version
Final published version

Published in
European Transport Conference Online 2020

Citation (APA)
Wesseling, B., de Bok, M. A., Spruijt, J., Usmani, O., & van Bree, T. (2020). Energy transition scenarios in the strategic freight model BasGoed. In *European Transport Conference Online 2020* Association for European Transport (AET).

Important note
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ENERGY TRANSITION SCENARIOS IN THE STRATEGIC FREIGHT MODEL BASGOED

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1. INTRODUCTION

A transition from the use of conventional energy carriers to more sustainable alternatives is an important policy objective to mitigate the impact of our energy consumption on earth's climate. This transition involves changes in the use of commodities in freight transport. This paper addresses how we improved the strategic freight transport model BasGoed for the Netherlands to better forecast the impact of energy transition scenarios on freight transport demand. BasGoed is developed as a tool for supporting policy decisions and produces forecasts for road, rail, barge and sea shipping. These forecasts are inputs for sectoral models of road, rail and barge transport.

Energy carriers such as coal, lignite, crude oil and fossil fuels make up for a substantial part of all freight transport in the Netherlands. The increase or decline in transport demand for these commodities is closely correlated to the speed of the energy transition. The uncertainty in future growth levels of energy carriers is one of the larger uncertainties in forecasting future freight demands, especially for rail and barge transport because of high market-shares for energy carriers.

In De Bok et al. (2018a) a broad range of sensitivity runs for BasGoed is presented. The results showed that the assumptions in the energy transition scenario have the biggest impact on forecasted freight transport demand.

The strategic transport model BasGoed has been improved to better capture the outcomes of the energy transition to be able to assess policy measures related to reducing CO_2 emissions. The global mix of energy carriers in energy production are our starting point in the input scenario. These global targets are translated into changes in economic structure (production and consumption of commodities by economic sector) using the outcomes of Energy System Simulation model (ENSYSI). This model is developed by the Dutch Environmental assessment agency (PBL) and provides quantitative information regarding developments in energy demand and production between 2010 and 2050.

In section 2 of this paper an overview of literature is given. Section 3 describes the policy context. Section 4 describes the modelling framework BasGoed. The different parts of energy transition scenario are given in section 5. Section 6 presents the BasGoed results from the energy transition scenario. This paper ends with a conclusion and discussion section.

2. LITERATURE

Most literature focuses on the environmental impact of freight transport itself, and tries to estimate the consequences of policies on this environmental impact. Researchers investigate the impact of low emission zones (Ellison et al. 2013) or compare policies and the vehicle related emissions of two different regions (Haakman et al., 2020) ,try to forecast the impact of certain policies related to more electric urban freight transport (Mirhedayatian et al., 2018) or forecast the impact of urban distribution centres (Van Duin et al., 2012). In Holquín-Veras et al. (2016) an overview is given of freight demand management in the context of public sector initiatives in sustainable urban freight systems while Lindholm (2010) investigate the awareness of local authorities for sustainable urban freight transport. The existing literature which focuses on the effects of the energy transition on freight demand is scarce. One exception is the PRIMES TREMOVE model (E3MLab, 2015) that takes into account changes in freight demand due to energy transition in the reference scenario . Still, the scope of the model is a lot more on the environmental impacts of freight transport itself with many vehicle types and fuel types. The impact of the energy transition on the volume of freight demand is a gap in knowledge.

3. POLICY CONTEXT

In the Netherlands the strategic transport model BasGoed is used as an instrument to outline the development of freight transport demand in the Netherlands and assess the impacts of policy measures. For instance, it was used to determine the effects of the new proposed distance based heavy goods vehicle charge in the Netherlands (de Bok et al. 2020) and (Muconsult et al. 2019). The increasing need for information on the impact of policy measures to reduce CO_2 emission is a potentiality for BasGoed model application. The national government produced a climate agreement (Ministry of economic affairs and climate, 2019) in which a cohesive set of proposals is laid out with the aim of achieving the carbon reduction target in 2030. In line with the Paris agreement the aim in 2030 is to reduce 49% of greenhouse gas emissions compared to 1990. The cohesive set of proposals in the climate agreement contains measures for different sectors such as the build environment, mobility, industry, electricity, agriculture and land use. It could be the case that some of the proposals in the sector mobility will be investigated using the BasGoed model while the plans for other sectors also impact freight traffic demand. Therefore, it’s essential that consequences of the energy transition are well captured within the model.

In this climate agreement an important substitute for crude oil, coal and natural gas is found in renewable energy sources such as geothermal, wind, solar and biomass energy. In the Netherlands there is lively debate on how desirable the use of biomass is, especially use of biomass for the generation of electricity, see for instance SER (2020). Although the climate agreement lays a framework for CO2 emission reduction, there is still uncertainty among the specific fulfilment of the climate goals.

4. MODELLING FRAMEWORK

BasGoed was developed over the past years as a basic model, satisfying the primary needs of policy making it is based on proven knowledge and available transport data (Tavasszy et al., 2010). The structure of the simple freight model follows the four-step freight modelling approach (see e.g. Ortúzar and Willumsen, 2011), including an additional module for maritime freight forecasts, container transport and vehicle type choice:

- Economy module: depicting the relation between the economy and transport, and generation of the yearly volumes (weight) of freight produced and consumed;
- Distribution module: determining the transport flows between regions for non-container transport;
- Modal split module: resulting inflows between regions per transport mode (barge, rail and road) for non-container transport;
- Multimodal transport chain model for container transport: resulting in container flows between regions by mode;
- Vehicle type choice module: resulting in trips and flows per vehicle type for road transport;
- Barge trip module: resulting in number of barge trips per transport relation
- Maritime Module: forecast of maritime freight transport flows to and from the deep sea ports in the Netherlands.

The traffic conversion and assignment is carried out after determining the freight transport demand in BasGoed. This step is completed in other uni-modal models for road, rail and barge.

Figure 1 gives a schematic overview of the BasGoed model and how these different modules are related to one another. The figure shows that BasGoed first produces a forecast for transported goods for road, rail barge and maritime transport. For barge and road transport these results are also translated to trips.

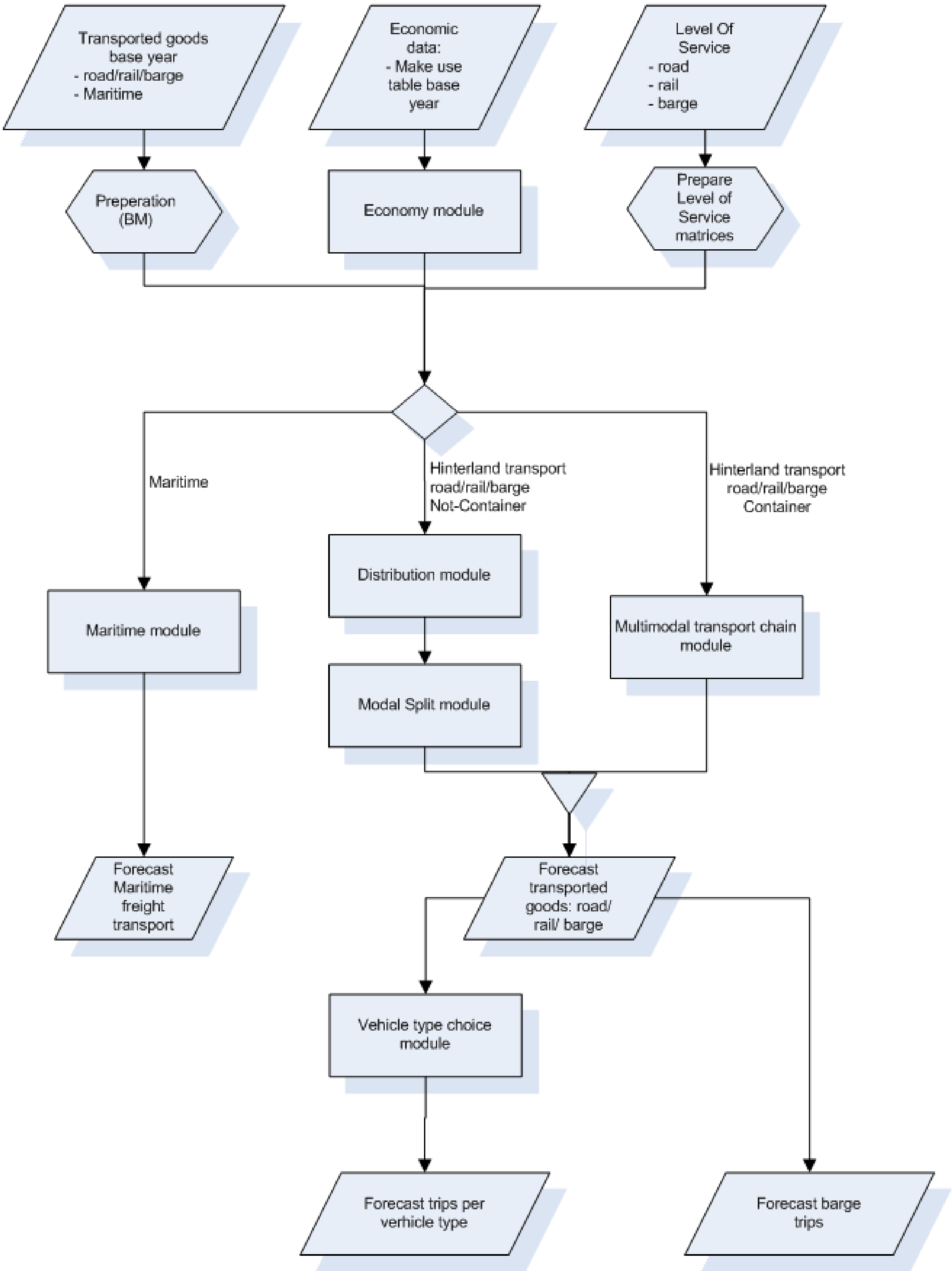

Figure 1: Schematic overview of the model BasGoed

The energy transition scenario has an impact on the results of the freight generation model forecasting the yearly volumes of freight traffic. The energy transition scenario impacts the generation of freight demand: the economy module. The remainder of this chapter describes the economy module in more detail other modules of BasGoed are also briefly discussed.

4.1 BasGoed Economy module

In freight demand modelling different techniques for freight generation are used. Three main modelling techniques can be distinguished (Ivanova, 2014): gravity models, multi-regional input output models and spatial general equilibrium models (SCGE). In BasGoed a national input output framework is combined with a gravity model that simulates the distribution of freight flows between regions.

BasGoed uses the existing economic module of the SMILE+ model for freight demand generation at regional level (see Bovenkerk, 2005; Tavasszy et al, 1998). This module is based on an input-output framework and translates economic scenarios to regional freight production and attraction forecasts (domestic and import/export). The economic model yearly updates a make-use table with 105 products and 83 sectors. The growth rates of these 105 products are related to sectoral growth rates of production, consumption and export.

The yearly make-use table contains results about production, consumption investments, imports and exports on a national level. This result is disaggregated in the regionalisation submodule within the Economy module. The geographical level of detail comprises 45 regions within the Netherlands and 312 international regions for the rest of the world. Input to this module are scenarios for the distribution of employment and population by region, and international trade volumes and scenarios.

International trade flows which have no origin or destination in the Netherland are not directly related to the I/O framework of the Netherlands, but these flows could transit through the Netherlands, e.g. from the UK to Germany. These transit tables are generated by this model based on the calculated export to the respective regions.

4.2 Other BasGoed modules

The second step of the model is the distribution model that generates origin-destination-commodity (OD-commodity) flows in tons, based on a double constrained gravity model. In the next step, the modal split model predicts the market share of road, rail and inland waterways for all non-containerized freight demand. Market shares are predicted for each OD-pair using a multinomial logit choice model. Both the distribution- and modal split models use transport costs and times between regions as inputs. The logsum of generalized transport costs over all modes (road, rail and IWW) are used as the generalized transport costs in the distribution model. In this way, the change in costs for road transport will not only affect the modal split, but also the generalized transport costs between regions and the spatial distribution of freight transport. For the derivation of the distribution and modal split modules see De Jong et al. (2011).

Parallel to the distribution and modal split module, the multimodal transport chain model predicts the market shares on these chains for container transport. For container transport multimodal transport chains are formed. The forecasted freight volumes are assigned to these multimodal transport chains with the use of a nested logit model. The multimodal transport chains simulate the hinterland transport and do not include maritime freight transport legs. For more information about the multimodal transport chain model see De Bok et al. (2018) and Wesseling et al. (2018).

The vehicle type choice for road transport decides which kind of vehicle type is used to transport the goods. A logit model is used to model vehicle type choice. Seven different vehicle types are distinguished: including trucks, trucks with trailer, tractor-trailer combinations, vans and a few others.

5 ENERGY TRANSITION SCENARIO

The energy transition scenario is incorporated in the economy model for BasGoed in three ways:

- Changes in production and intermediate consumption of energy carriers;
- Investments necessary for the energy transition;
- Changes in final consumption of energy carriers.

Changes in production and intermediate consumption of energy carriers from ENSYSI is incorporated in the economy model for BasGoed in two ways. First of all, the production function in the use table is altered by substituting one product or service by another. Second, the growth levels for consumption, production and export are modified for relevant economic sectors. The investments needed for the energy transition are also taken into account. Changes in final consumption (i.e. investing in isolation of residential houses and therefor using less energy) are captured by altering growth rates of consumption for certain sectors. In Figure 2 a schematic overview is given of how the energy transition scenario in the economy module of BasGoed is implemented. The figure shows how the three input changes are translated to the economy module of BasGoed and which quantitative sources are used to model the changes due to the energy transition. The remainder of this paragraph will discuss the three input changes of Figure 2 in more detail.

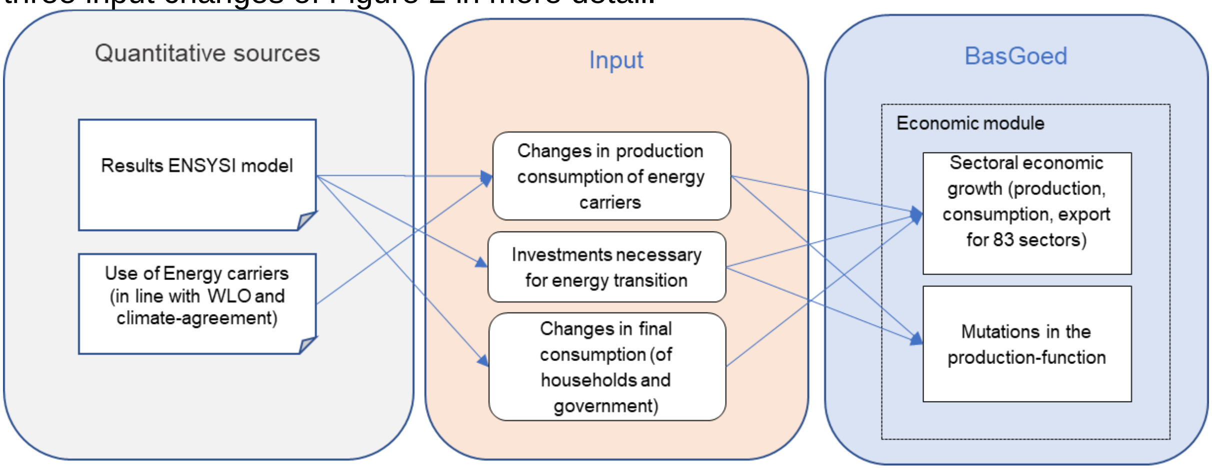

Figure 2: Translation of the energy transition scenario to the economy module of BasGoed.

1. Changes in use of energy carriers

The changes in production and consumption of energy carriers are derived from the Energy System Simulation model (ENSYSI). More information about the ENSYSI model is given in paragraph 5.1. The change in use of energy carriers is translated to mutations in the production function used in the BasGoed Economy module. In the production function good *a* is produced in sector *B* by good {*x*,*y*,*z*}. The mutation that can be done is substituting good *x* by good *w*. Where energy transition involves a shift from nonphysical energy sources, e.g. electricity to hydrogen, or a shift in a sector that doesn't produce a physical product, changes in the use of energy carriers is not translated to mutation of the production function but rather in changes in sectoral growth levels.

The downside of using only the Energy System Simulation model is that the change in the use of energy carriers is determined by cost-effectiveness of the reduction in CO_2 while there is a lively debate on whether certain changes are desirable as in the beforementioned discussion on biomass.

As a second source of information the change in use of energy carriers in the WLO (Matthijsen et al. 2015) is used. The distribution of energy carriers is slightly altered to account for changes that are made in the climate agreement (Schoots, K. & P. Hammingh, 2019), (Hekkenberg et al., 2019), (Ministry of economic affairs and climate, 2019). The changes in the use of the most important energy carriers: coal, crude oil, natural gas and biomass are used to calibrate the energy transition scenario in such a way that the BasGoed results are aligned with the distribution of energy carriers from Table 1. In Table 1 the use in PJ of the four energy carriers of the original WLO is given and the use of energy carriers changed to the most recent insight (WLO +E).

Table 1: Use of energy carriers in the Netherlands in PJ (the original long term scenario is the first two rows the rows with WLO+E gives the most recent figures that incorporates the climate-agreement of the government)

Coal	2014	2030	2040	2050
WLO Low	372	182	161	140
WLO High	372	194	179	144
WLO+E Low	372	129	105	105
WLO+E High	372	129	105	105

Crude Oil	2014	2030	2040	2050
WLO Low	1203	1220	1200	1180
WLO High	1203	1246	1245	1243
WLO+E Low	1203	1163	1163	1163
WLO+E High	1203	1115	1115	1115

Natural Gas	2014	2030	2040	2050
WLO Low	1276	1035	867	679
WLO High	1276	992	794	600
WLO+E Low	1276	944	812	679
WLO+E High	1276	717	659	600

Biomass	2014	2030	2040	2050
WLO Low	118	319	370	421
WLO High	118	396	479	561
WLO+E Low	118	161	291	421
WLO+E High	118	224	393	561

2. Investments necessary for the energy transition

Structural changes in the economy necessitates investments. For instance, changing the heating of an office from natural gas to renewable sources need investments. The quantitative source used for the investments is ENSYSI. All 250 technologies that are modelled in ENSYSI are coupled into 7 categories. Figure 3 presents the extra investments needed In the year 2030. For this figure an ENSYSI scenario was used in which all CO2 emissions in 2050 are reduced by 95 percent compared to 1990. This scenario is compared to a business as usual scenario with continuation of existing policies.

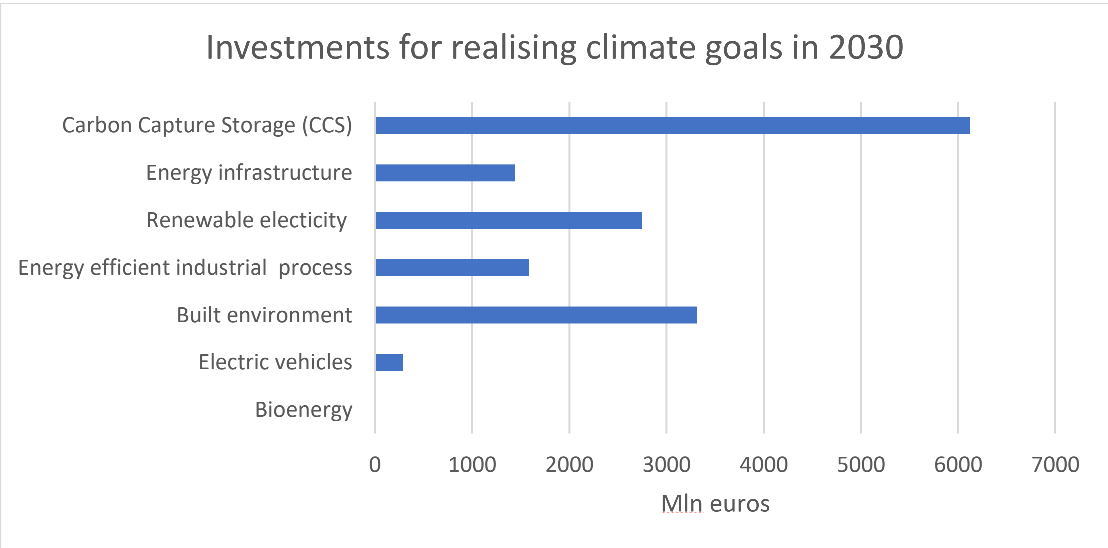

Figure 3: More investments in energy technology in 2030 when 95 percent reduction of CO_2 emissions in 2050 need to be reached compared to a business as usual scenario.

3. Changes in final consumption

The consumption of households (and the final consumption of the government) changes during transition to a more sustainable energy system. For instance, a household makes an investment in solar panels and uses less electricity from other sources. The transition in final consumption is also derived from results of ENSYSI.

The changes in final consumption are translated to changes in sectoral growth levels of consumption that are inputs for the economy module of BasGoed. An assumption that is used while changing the final consumption is that the total consumption is equal to the business as usual situation. Only the kind of goods that are bought as final consumption will change.

5.1 ENSYSI

In this section the Energy System Simulation model (ENSYSI) is briefly explained. ENSYSI is developed by the Dutch Environmental assessment agency (PBL) and provides quantitative information regarding developments in energy demand and production between 2010 and 2050 (Koelemeijer et al. 2015).

The model has as main inputs the developments of economic sectors (such as the amount of houses and offices, transport distance, economic development of industry), prices of primary energy carriers (coal, oil, natural gas, biomass) and energetic and cost parameters of more than 250 technologies (such as off-shore wind, electric cars, types of houses) that can evolve over the simulated time period.

For each timestep, the demand and supply of energy carriers is matched. For all carriers except electricity, annual total demand and supply is balanced. For electricity, demand and supply are balanced on an hourly basis, to be able to capture the effects of non-dispatchable production from solar-PV and wind power. Deficits in supply trigger investments for the following year.

Energy system developments are simulated based on investment decisions of actors (large or small companies, house owners, farmers, etc.). In the model, the investment decisions by actors depend on different aspects: total costs of a technology (capital costs, fuel costs, O&M costs, etc), the investment costs alone (to simulate an investment barrier), whether or not targets for CO_2 reduction exist and their height, the social attitude of actors, and the complexity of a technology. These aspects are referred to as ‘motivation factor aspects’, as they describe the motivation of actors to choose certain technologies above others. Within each group of actors, different actor types are distinguished ('innovators', 'early adopters', 'majority' and ‘laggards’), which differ in the weight that they give to the motivation factor aspects. For example, innovators can give more weight to the aspect social attitude, while the majority and laggards give more weight to the aspect costs. In the model, policies, like CO_2-pricing or setting standards, influences actor behaviour.

The maximum possible increase of the stock of a technology in a year (the potential) follows an s-curve in case of technologies that are in an early or more mature development stage. This implies that the potential for further growth of a technology increases if the application increases. For mature technologies, the potential is unlimited, or the potential has a fixed value. Inputs of biomass and other energy carriers can be constrained as well as the storage of CO_2 in geological reservoirs.

Energy in- and outputs of technologies and technology costs are based on a variety of sources and described in more depth in the chapters on model input data. Cost reduction of technologies is based on the so-called learning curves. Technological learning can be exogenous (in which case a scenario for the global growth of installed capacity (stock) must be provided, or endogenous, in which case the application of a technology as calculated by the model influences its cost development.

5.2 Long term transport scenario's WLO

Starting point for the analysis are the long-term scenarios for the Netherlands, the so-called WLO scenarios ('Future outlook on welfare, prosperity and the human environment'). These scenarios are formulated by the CPB Netherlands Bureau for Economic Policy Analysis and PBL Netherlands Environmental Assessment Agency. They describe two base cases: the High and Low scenario (Romijn et al, 2016). Both scenarios include a consistent set of assumptions on economic development (domestic growth by industry sector and international trade), infrastructure development, fuel prices, and logistic efficiency. Table 2 provides a global overview of the main assumptions in the High and Low scenarios.

Table 2: Main scenario assumptions in the High and Low scenario in WLO2. Source: Romijn et al. (2014).

	High scenario:	**Low scenario:**
World economy	Strong growth	Slow growth
International trade	Strong growth	Slow growth
Strategic position Dutch deep sea ports	Remains constant	Remains constant
Industrial development	Large service sector	Small service sector
Climate policies	Substantial: reduction of coal and oil volumes	Moderate: no reduction of coal and oil volumes
European transport policy	Neutral trend	Neutral trend
Logistical organization	Widespread upscaling, consolidation and increasing efficiency	Minimal upscaling, consolidation and increasing efficiency
Dutch policy	Minimal differentiated	Minimal differentiated

The WLO scenario are long term scenarios for the Netherlands that are used for a variety of models and tools as scenario. The WLO scenario assumes a substantial climate policies in the High scenario and moderate climate scenarios in the Low scenario. In preliminary forecasts with the freight model BasGoed, this assumption was implemented on a general level. Currently, the higher reduction of coal and oil in the WLO High scenario is in more detail translated into sectoral growth for production and consumption. Including the energy transition in the scenario results in lower use of coal and oil in the Netherlands in the High scenario compared to prior forecasts.

5.3 Changes in the distribution of production and consumption per zone.

Besides overall growth levels for different commodities, the energy transition scenarios also have an impact on the spatial transport patterns of energy carriers. The energetic use of coal will decline the coming years due to the closure of coal power plants; non energetic use for steel production, however, may have a different development. Usage for both forms have a different spatial distribution. Therefore a new module was implemented in BasGoed to capture disruptive spatial patterns of freight flows. For coal transport a new spatial distribution in terms of production and attraction per zone is inserted in to the model. This is done by changing the production and consumption per zone between the economy module and the distribution module. Maritime freight forecasts are also altered to be in line with the assumed location of consumption of coal. Container transport isn't changed because coal is almost never transported in containers.

The changes in distribution of consumption of coal per zone is modelled with the new developed spatial pattern module. The schematic overview in Figure 2, of how the energy transition scenario in BasGoed is developed, can be expended with how the input for the spatial pattern module is derived. In the energy transition scenario closure of all coal based powerplants in the Netherlands and Germany before 2030 is assumed. More than 50% of all coal transport in the harbour of Rotterdam is transhipment to Germany of which around 50% is used in coal powerplants (Port of Rotterdam, 2018). The use of coal in 2030, 2040 and 2050 given in Table 1 is coal for other industrial processes then for the production of electricity. The scenario for the spatial pattern module is based on an assessment of all current locations of coal powerplants and all steel production facilities in the Netherlands and Germany. This assessment leads to relative shares of consumption of coal per zone.

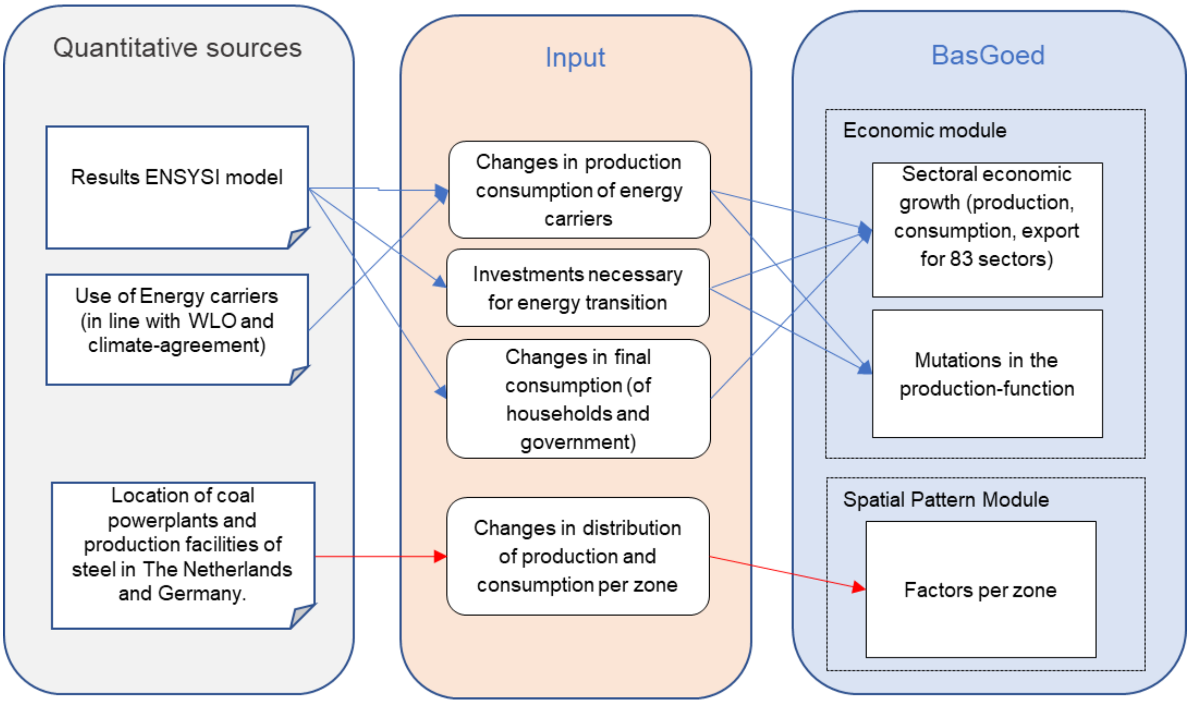

Figure 4: Overview of the implementation of energy transition scenario in BasGoed.

6 RESULTS

The energy transition scenario are analysed in BasGoed to show the impact on the freight forecasts. In BasGoed 13 commodity groups are used. The extra transport of biomass is simulated in commodity group 1 “products of agriculture, forestry and fish”. Table 3 shows the result of the energy transition scenario. The impact of the scenario on the forecast of the three modalities is different. The rail forecast declines (16 %) mostly because of the decline in coal transport. Coal is the largest commodity in rail transport. The road forecast is larger after implementation of the energy transition scenario because of growth in commodity group 1 due to increase of biomass transport, and partly because of extra growth in commodity groups 12 and 13 due to extra investments necessary for the energy transition.

The total freight demand increases with 3% after implementation of the energy transition scenario. This can be explained by the fact that biomass has a lower energetic density than coal, and natural gas. Natural gas and crude oil are mostly transported with pipes and sea-shipping. Also the extra investments necessary for the energy transition lead to more freight transport.

Table 3: Results of the energy transition scenario for road, rail and barge transport for 13 commodity groups, for 2040 in the High scenario

		road				rail				barge			
			2040 High				2040 High				2040 High		
	x1000 ton	2014	reference	energy	verschil	2014	reference	energy	verschil	2014	reference	energy	verschil
1	Products of agriculture, hunting, and forestry; fish	90,745	122,662	133,625	10,963	1,901	3,052	3,119	67	19,296	32,496	35,000	2,504
2	Coal and lignite	976	783	773	-10	9,028	11,517	2,272	-9,246	32,125	25,996	13,602	-12,394
3	crude petroleum and natural gas	7	15	13	-1	56	39	37	-2	174	145	135	-10
4	Metal ores	63	86	102	16	6,241	6,078	6,179	101	30,186	29,663	29,817	154
5	Salt, sand, gravel and clay	100,402	102,623	108,787	6,164	471	468	478	10	76,678	75,942	80,402	4,460
6	Coke and refined petroleum products	10,976	14,905	14,925	21	1,360	1,539	1,557	18	58,548	69,080	69,585	505
7	Chemicals, chemical products	61,057	104,249	106,383	2,134	4,809	8,943	8,967	24	50,318	92,086	92,735	649
8	rubber and plastic products	20,674	30,668	31,999	1,331	4,685	8,363	8,438	75				
9	Basic metals; fabricated metal products	43,143	53,388	57,038	3,650	4,446	6,593	6,718	126	16,110	24,214	24,879	664
10	Other non metallic mineral products	78,700	95,927	103,056	7,129	1,459	2,195	2,178	-17	7,730	11,196	11,332	136
11	Food products, beverages and tobacco	169,598	215,775	216,214	439	4,167	5,473	5,083	-390	27,434	39,394	37,866	-1,528
12	Machinery, equipment and transport equipment	47,832	69,678	79,793	10,115	2,398	3,580	3,617	36	6,144	9,555	10,037	482
13	Other goods and waste	122,914	156,802	165,886	9,084	5,047	7,335	7,289	-46	20,847	29,917	30,382	465
	Total	**747,088**	**967,560**	**1,018,594**	**51,034**	**41,382**	**56,819**	**47,502**	**-9,318**	**350,276**	**448,047**	**444,210**	**-3,837**

BasGoed produces forecasts for maritime transport, in Table 4 maritime forecasts for the High scenario are depicted. Prognoses for the years 2030, 2040 and 2050 are included in the table. The table shows rapid decline of coal transport between 2014 and 2030 because of closing of coal powerplants in the Netherlands and Germany. After 2030 there is a only small decrease in transport of coal transport between 2030 - 2040 (-1,4% per year).This decrease is in line with coal usages in Table 1.

Table 4: Maritime transport forecasts for 2030, 2040 and 2050 in the High scenario including the energy transition scenario

commodity	2014	2030	2040	2050	groth per year '14-'30	growth per year '30-'40	growth per year '40-'50
1 Products of agriculture, hunting, and forestry;	23,888,479	40,802,212	55,049,965	73,354,805	3.4%	3.0%	2.9%
2 Coal and lignite	60,824,327	19,255,144	16,795,004	15,120,103	-6.9%	-1.4%	-1.0%
3 crude petroleum and natural gas	96,069,309	160,323,649	167,322,630	171,761,042	3.3%	0.4%	0.3%
4 Metal ores	40,654,570	43,630,366	40,180,466	36,919,022	0.4%	-0.8%	-0.8%
5 Salt, sand, gravel and clay	14,248,257	17,482,467	17,941,766	18,567,554	1.3%	0.3%	0.3%
6 Coke and refined petroleum products	130,345,950	156,593,862	150,075,586	162,557,936	1.2%	-0.4%	0.8%
7 Chemicals, chemical products	43,946,841	78,262,993	101,301,115	134,500,302	3.7%	2.6%	2.9%
8 rubber and plastic products	9,579,530	17,867,495	22,959,861	29,454,134	4.0%	2.5%	2.5%
9 Basic metals; fabricated metal products	33,407,408	52,107,726	64,980,585	80,218,392	2.8%	2.2%	2.1%
10 Other non metallic mineral products	7,359,233	10,564,817	12,291,423	14,144,925	2.3%	1.5%	1.4%
11 Food products, beverages and tobacco	40,018,650	58,255,731	69,246,654	83,459,921	2.4%	1.7%	1.9%
12 Machinery, equipment and transport equipme	14,577,359	20,571,344	23,958,671	28,226,774	2.2%	1.5%	1.7%
13 Other goods and waste	38,512,278	63,016,496	76,337,354	93,077,292	3.1%	1.9%	2.0%
Total	**553,432,191**	**738,734,302**	**818,441,080**	**941,362,202**	**1.8%**	**1.0%**	**1.4%**

7 CONCLUSION AND DISCUSSION

In this paper we illustrate how the energy transition in other sectors then mobility have a huge impact on future freight demand. It is of vital importance to take these changes into account within a strategic freight transport model for forecasting future transport demand for policy assessment.

A realistic energy transition scenario is taken as input from an energy system simulation model, that models all the responses in the energy system, also second order reactions such as extra investments are taken into account. n. A downside of using the results from an energy system simulation model is that the results from the model can be inconsistent with the latest trends in climate policies that are input to the strategic freight transport demand model. Therefore the energy transition scenarios are calibrated to the usage of coal, oil, natural gas and biomass derived from assessment studies of the Dutch Environmental assessment agency (PBL).

The results from BasGoed show realistic and plausible results when including the energy transition scenario. The rapid decline between 2014 and 2030 of coal transport was not visible in the results before implementing the energy transition scenario. A strategic model like BasGoed has its limitations to implement disruptive developments such as the energy transition. The economy model of BasGoed has limitations to what extend changes in the production and consumption of commodities can be simulated. Alterations of production and consumption growth rates have complex impacts on other commodities due to the interdependencies between producing and consuming industry sectors in the economy, and the related commodities. Changing input output factors in the model is not straightforward in the current implementation of economy model: mutations in the production function need reduction of one product by another product rather then changing input output factors directly. Mutations in the production function are not always possible, when the sector does not produce physical goods or the mutation involves nonphysical goods.

Furthermore, the origin of biomass products is not known in advance and therefore challenging to come up with a credible distribution for this commodity. Currently, the model extrapolates the pattern of observed transport movements. In the commodity categorization, biomass is included in the agriculture and forestry products. Therefore the results show an increase of road transport. The scenario could be further improved by defining an alternative pattern for the production of biomass. Production location could be switched to regions with (an abundance of) forestry instead of agricultural regions. That might leads to a different, possibly more plausible, modal split. Although, it still would imply several assumptions.
This paper elaborates the incorporation of energy transition scenarios in freight transport demand forecasts. The figures shown in this article show how the transition of the energy carriers change the freight transport forecast. Still, the outcome of the energy transition remains uncertain because of possible changes in policies, new insights, an ongoing debate on the desirability of certain technologies, technological innovation and other disruptions in the world’s energy system. Therefore, the results in this paper should be considered in his period of time since rapid developments. It is recommended to update this scenario every few years to keep in line with the latest insights.

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