Groen Gas - Sustainable Supply Chain Manager

New combinations in the transition towards a sustainable energy production

Frans Debets[1] und Manuel Osmers[2]

Abstract

Although the production of sustainable energy has grown rapidly, the experience of the last 10 years has proved that the road towards sustainability is a bumpy one. If we want to reach our goals we have to have broad consensus on three basis questions: *Why* do we want this, *What* can we do to reach our goals; *How* can we do this.

An analyses of the sustainable energy production shows that the largest part of the production is based on biomass. The fermentation of biomass into biogas in digesters is one of the methods. The development of biogas has been successful but now stagnation is looming. Despite this stagnation, new opportunities present themselves. A case in Coevorden is described as an example of developing new combinations. To facilitate new developments a software tool called the *Sustainable Supply Chain Manager* has been developed as a "deliverable" of the Interreg NSR IVA project Groen Gas/ Grünes Gas D-NL by the Carl von Ossietzky Universität of Oldenburg. Three cases were used to validate the tool: the case *Gemeinde Dornum* (D), the case *Gemeinde Westerstede* (D) and the case *Energy-Transition-Park in Coevorden* (NL).

In this paper we briefly look at the developments in the field of sustainable energy production, in both Germany and the Netherlands. The case Coevorden is presented as an example of *Neue Kombinationen*. The SSCM tool can be used to find the best option for new developments.

1. Introduction

The members of the European Union follow the Renewable Energy Directive of April 2009. The overall goal is to cover 20% of the energy use with energy from sustainable production. Part of this ambition is to reach a level of a 10% sustainable share in the transport fuels.

Each member of the EU will contribute to this goal according to its respective capabilities and ambitions. For instance Sweden has the possibility to use its vast hydroelectric potential and wood production, their renewable energy goal is 50%. The Netherlands has limited possibilities to generate renewable energy, their 2020 goal is 14%. Germany has set its goal on 18%.

In 2009 the overall EU status quo was about 8%. Some countries were already very near their 2020 goal, e.g. Sweden. Others still had a long way to go; Germany had reached 10% , the Netherlands reached 4%. [1], [2]. In 2013 the Netherlands had reached 4,5%, Germany has reached 12%.

These percentages are linked with the *gross energetic end use*. The definition of "*end use"* is different from the *primary energy use* that is calculated from the use of primary energy materials, basically the volume of oil, coal and gas. The *gross energetic end use* is based on the total energy use of all end users, this does <u>not</u> include the use of primary energy for non-energetic purposes, for instance oil as a raw material for the chemical industry and does not include the losses in generating and transporting electricity. As an illustration: the Netherlands have a *total primary energy use* of 3200 PJ, the *gross energetic end use* is 2200 PJ. The 2020 goal of the Netherlands is 14%, based on the end use of 2200 PJ this would be: 308 PJ. Germany has an

[1] Ing. F.L. Debets , Debets b.v., Groningen, Nederland

[2] Dipl.-Inform. Manuel Osmers, Carl von Ossietzky Universität Oldenburg, Deutschland

Endenergieverbrauch of approx. 9000 PJ, the 18% goal for 2020 is: 1620 PJ. Both countries try to reduce the end use, the Netherlands has set its own goal to reduce at least 100 PJ by 2020. If the end use can be reduced to 2000 PJ, the 14% 2020 goal drops from 308 PJ tot 280 PJ.

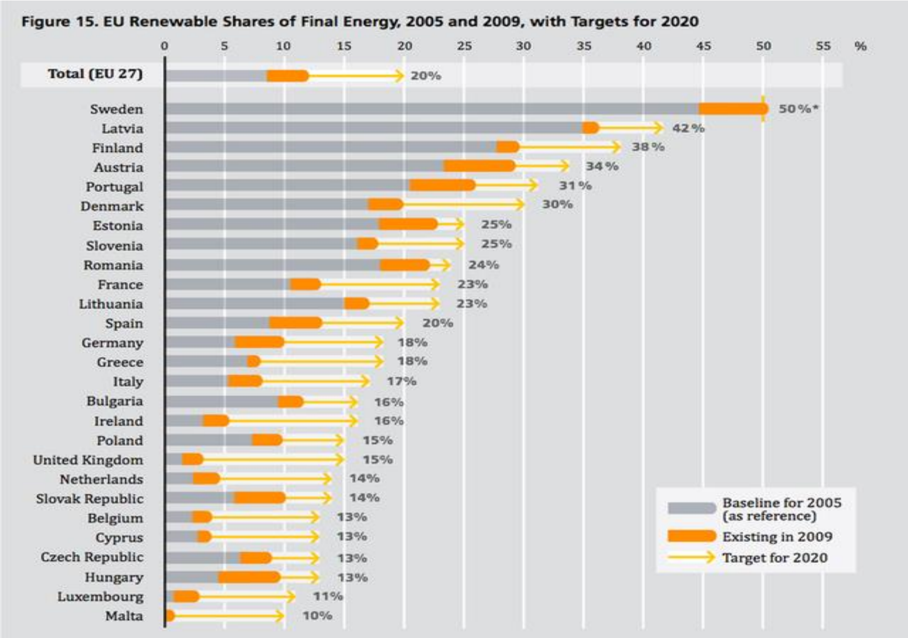

Table 1. The EU targets for 2020 and the status quo in 2005 and 2009.

It must be stated that energy use is closely related to the growth of the economy. The Netherlands that now have a *primary use* of 3200 PJ, used in 1960 approx. 1000 PJ. In 1980 its use crossed the 3000 PJ line. The last few years due to the economic crisis and the efforts to reduce energy most European countries managed to stabilize or even reduce their total energy demand. The world wide trend is that the more developed countries stabilize or reduce their energy demand, the new economies still have a strong growth of their demand. E.g. In 2012 was the fourth year since 2008 that the G7 countries' energy demand shrunk: 1.6% in 2012. N.b.: the demand in Germany and the Netherlands rose slightly.

Although the theme of energy reduction and the switch to a sustainable production has a high political and public profile and is supported with large budgets, the actual reduction and the alternative production is not yet impressive in both Germany and the Netherlands.

In this paper we discus some aspects of the stagnation, public support or acceptance is one of the aspects that will get attention in this paper.

Based on the assumption that problems and threats not only lead to stagnation but also to new approaches and concepts, we analyse an interesting case of "neue Kombinationen" in which local governments and commercial developers try to find a new way to serve the cause of the sustainable energy.

2. A bumpy road

The transition towards a sustainable society is a complex process. Policymakers, companies and the people share the vaguely defined ambitions, but the "drivers" behind the ambition (why do we want this?) and the concrete steps forward, lead to intensive discussions. At this moment every windmill or fermenter seems to be a "battle ground" where societal forces clash. The road towards sustainability is a bumpy one and it is littered with broken dreams, disappointing failures, inspiring successes and promising breakthroughs.

An interesting phenomenon is that society as a whole seems to agree on the goal, there is, in general, consensus on the question *What Do We Want*: decarbonize, less use of fossil fuels, less dependency on external sources. The consensus is less on the question *How can we Do It*? E.g.: legislation to reduce energy leads to effective resistance from target groups; the development of wind power or biogas plants lead to intensive controversy in the production regions. The consensus on the basic question *Why Do We Want This* is not developing well either. Four "drivers" behind this *Why* question are:

1) Climate change.
   The production green house gas must be stopped.
2) Supply security
   One day oil and gas will not be available anymore, and our dependency on suppliers of fossil fuels make us vulnerable, therefor: we must now invest in sustainable production.
3) Environment
   Many of our environmental problem are related to the production, transport and use of fossil fuels. We must stop that.
4) New economic chances
   The transition towards sustainable energy provides opportunities for new economic activities and jobs in our countries.

This mixture leads to complex discussions, polarised positions and shifting arguments. Developments in Ukraine or the Middle East lead to more appreciation of point 2; extreme weather conditions or IPCC reports shift the focus to 1; success or failure of new industries influence the importance of 4; problems with shale gas, problems in the nuclear industry or a blow out in the Mexican gulf brings nr. 3 back into the focus. In the heated debates the opponents use strong arguments (*it is 5 minutes to twelve….)* leaving the public and the political leaders behind in confusion.

To develop an effective strategy towards a sustainable society it is important to have a broader consensus and a consistent communication on those three questions: *Why* do we want this, *What* can we do to reach our goals; *How* can we do this. These are also important in the development of local initiatives or individual projects.

2.1. How can we do it?

The use of sustainable energy is, in the public eye, mainly the use of sustainable electricity. In Germany approx. 25% of electricity consumption is produced with sustainable systems, for the Netherlands it is 10%. But the energy use is much more than just electricity: transport fuels and energy for heating must also be taken into the account.

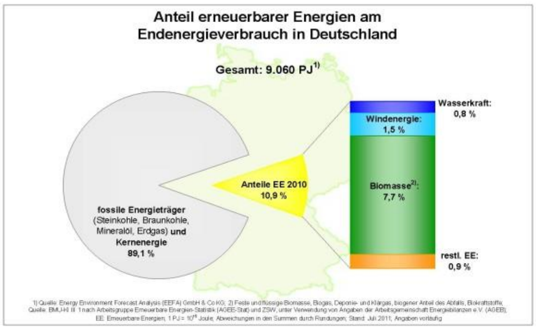

Table2: The percentage of renewable energy, based on the end use, in Germany 2010

The above illustration about the status quo in Germany (2010) indicates the dominance of fossil fuels. The 10,9% sustainable energy is 987 PJ or 274 TWh.

For instance the impressive development of windpower "only" brings in 1,5% (38 TWh), the enormous amount of solar power installations produced a volume energy that is too small to represent with a visible slice of the pie. n.b. The wind in production in Germany and the Netherlands kept on growing after 2010

year	2010	2011	2012	2013
Installed GW windpower in Germany	27	29	31,3	34,6
Produced TWh	37,8	48,8	50,6	53,4
Produced TWh in Netherlands	4,5	4,7	4,9	5,5

Table 3: The production of wind energy in Germany and the Netherlands.

The illustration below represents the situation (2011) in the Netherlands, the sustainable slice is only 4%. The 2014 situation is not very different, the Netherlands still hovers around 4,5% (95 PJ)

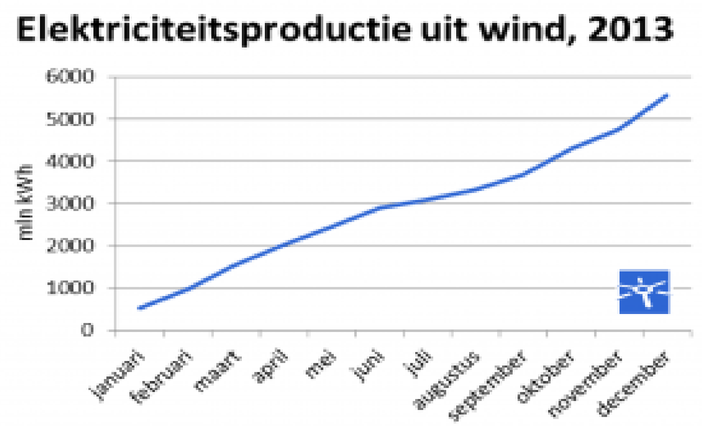

Table 4: The production of wind energy in 2013 in the Netherlands

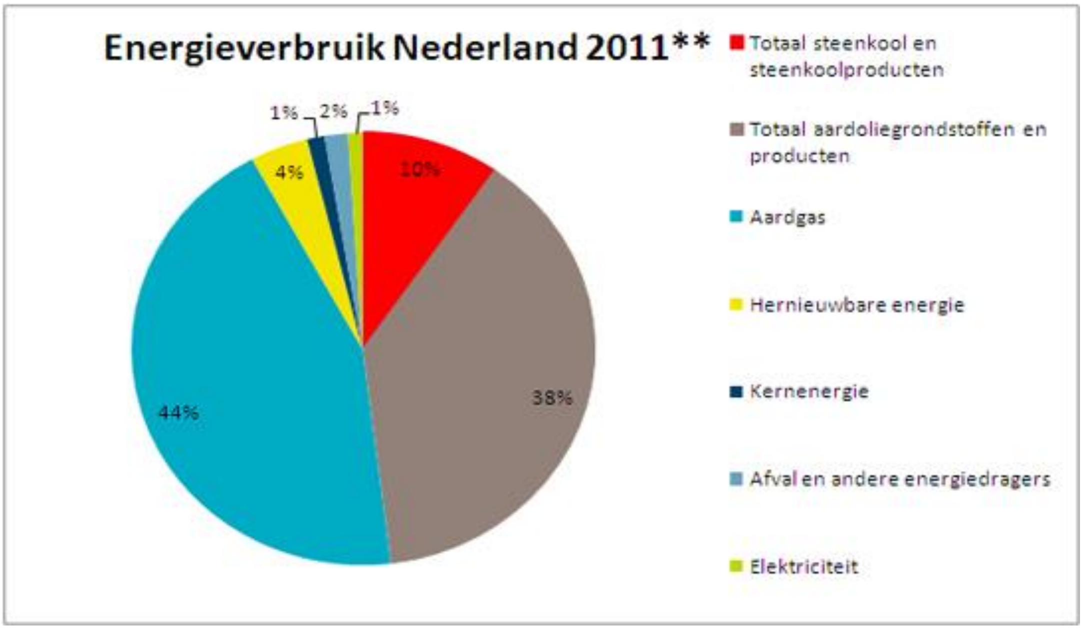

Table 5: The end use of energy in the Netherlands and its sources.

In both countries biomass is the dominant source of sustainable energy (Belgian is also presented hereunder), more than 70% is biomass based.

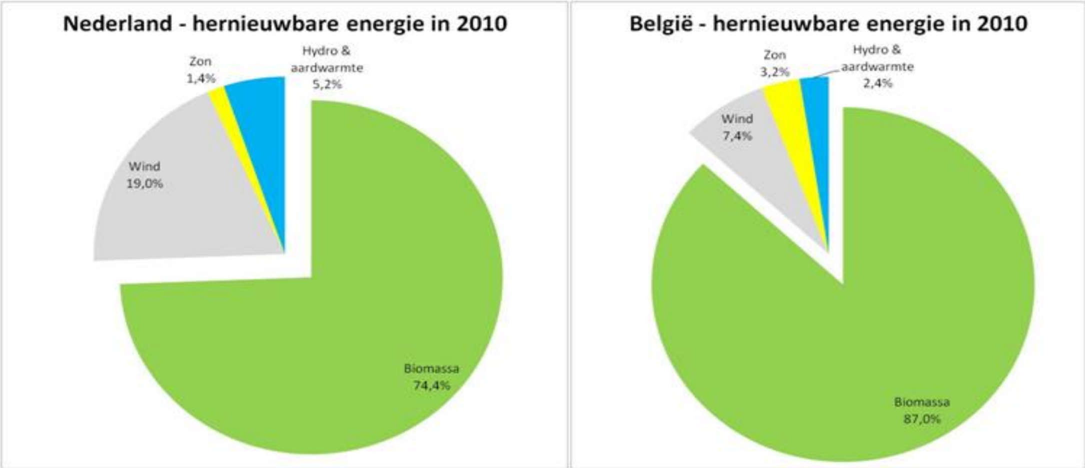

Table 6: Renewable energy in the Netherlands and Belgium in 2010.

Biomass use can be wood to co-fire the coal firing electricity plants, or it is waste that is burned in incineration plants, or wood burning in households, or digestable materials that are used in fermenters to produce biogas, or ethanol or biodiesel as transport fuel. The illustration below indicates the versatile use of biomass in Germany: 45,5% is used to produce heat, 12,1% produces electricity, 13% produce transport fuels.

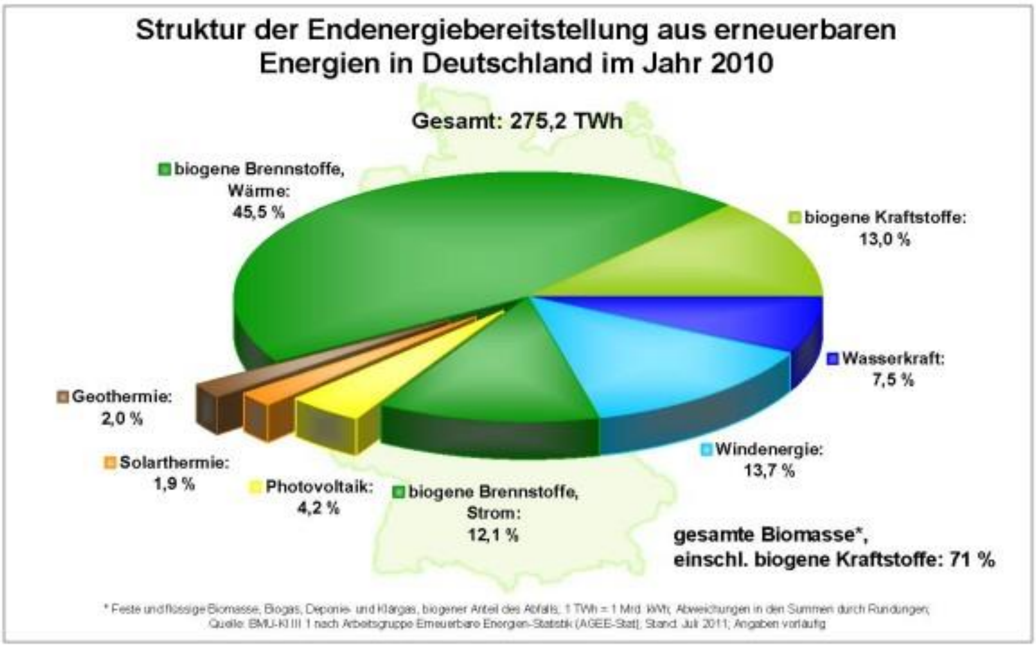

Table 7: Renewable Energy in Germany in 2010

2.2. Biogas

One of the biomass conversion routes is the fermentation into biogas, this can be used in a gas motor (heat power combination) that drives a generator to produce electricity or it can be upgraded to natural gas standards and distributed through the natural gas infrastructure. The illustration below indicates the rapid growth of the number of biogas systems in Germany and its capacity towards approx. 3.500 MW in 2013. These systems produce approx. 23 TWh electricity, comparable to roughly 50% if the wind power production.

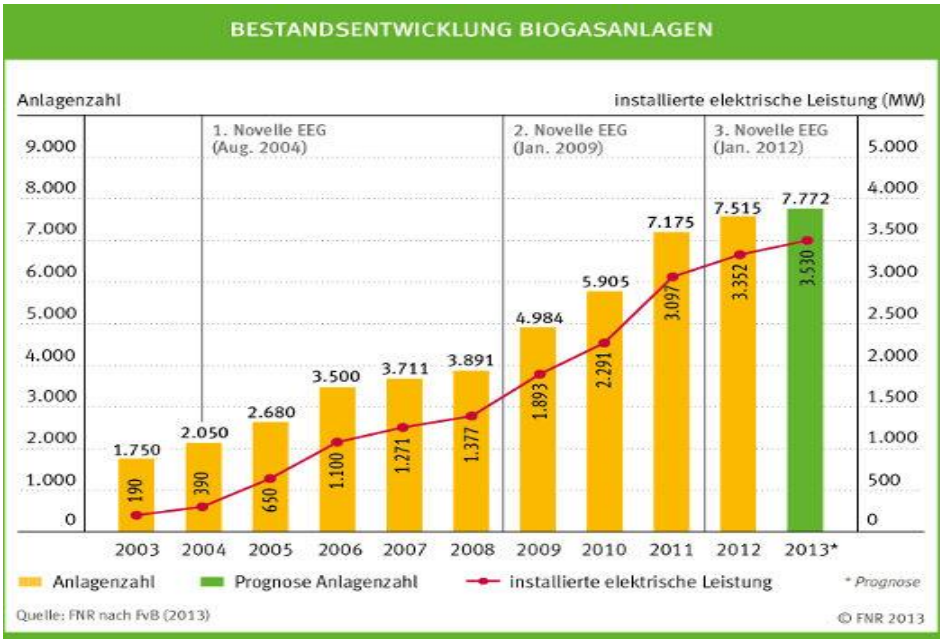

Table 8: Biogas systems in Germany.

In the Netherlands the number of installations grew rapidly after 2005, but stagnated after 2010, the number is approx. 110 with a capacity of 110 MW and a production of approx. 0,7 TWh. This production has not changed much since 2010.

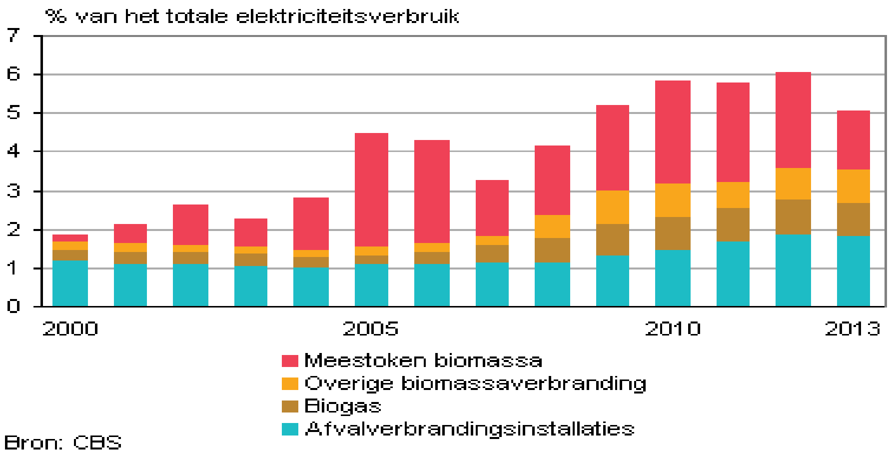

Table 9: Renewable electricity production in the Netherlands 2000-2013

2.3.1 Stagnation of the biogas industry

The rapid growth of the biogas industry took place, mainly, in the agriculture industry. Farmers started to ferment agri-waste products like manure and crops like maize or sugar beet. To be able to have a viable business case, subsidies were needed to support this development. The kWh price could go up, in Germany, to 30 cents per kWh if all bonus possibilities were used. The rapid growth of the installed capacity in Germany led to several effects: the land lease prices increased; the landscape changed due to the increase of maize production; the traffic of input and output transport in the rural areas increased; technical problems, like fermenter explosions, were new and attracted much public attention; the price of input materials rose – the footloose biomass traders took advantage of the biogas plant owners. Other reasons behind these effects can also be identified, e.g. the growth of the intensive animal production also contributed to the "Vermaizung"; the increase of commodity prices on the world market also inflated the lease prices, but the negative aspects and connotations "stick" to the biogas industry.

Next to these negative aspects were the impressive contribution to the *Energie Wende*; new economic activities started and grew out to export business for the world market; extra income for the farming community. The recent discussion about the support instrument, the EEG[3] , indicates that the biogas industry cannot grow as brisk as before. The growth will be "capped" to an annual growth of 100 MW, the bonus system will be reduced, the payout per kWhe will be reduced to 13,39 cent per kWh for the larger systems up to 20 MW, up to 500 kW the "Vergütung" is 15,26 cent.

The SDE[4] in Netherlands is a somewhat different subsidy system but in general it is the same: it provides for a long period (12 – 15 years) a guaranteed price per kWh. For the SDE the annual budget (€3,2 10^9 in 2014) is limited, the government wants to promote a "scramble" for the budget to get the most kWh per Euro. In the SDE system one can tender in tranches, in the first tranches the price is low but the chance to get the 12 year contract is high, in the next tranches the price is higher but the chance is smaller. For electricity production (in SDE 2014) with fermentation the first tranche is 19,4 cents per kWh, in the third tranche it is 22,7 cents per kWh. Most new applicants decide to produce green gas, and not electricity. The SDE 2014 price is 48,28 cent per m^3 (tranche 1) to 60,1 cent per m^3 (tranche 3), in kWh (based on 8,61 kW per m3 gas): 5,6 cents per kWh to 6,9 cent per kWh.

The described stagnation is an example of developments that interact with the observations described under2: an effective strategy towards a sustainable society calls for a broader consensus on three essential questions: *Why* do we want this, *What* can we do to reach our goals; *How* can we do this.

2.4.2 New chances, a way out…

Although the growth of the digester industry will slow down, the question can be asked if the transition towards a sustainable energy system can be successful without the production of biogas. The technology will continue to improve and the amount of fermentable biomass in modern countries is too large to ignore the potential of fermentation.

Some new developments may offer new opportunities for the fermentation technology. Three relevant developments are mentioned hereunder.

1) The peak production of wind power and solar power calls for a backup capacity that can be activated on short term notice. The biogas units can be switched on and of rapidly, provided that they can store the biogas production for some time.
2) The fermenters are not only energy systems, they are also systems of biomass conversion. They can be used as nutrient production facilities. In the Netherlands there is a great need for manure and slurry processing so that the surplus of Phosphate and Nitrogen can be concentrated and be made exportable.
3) The development of Liquid Natural Gas (LNG) as transport fuel is promising. LNG has many advantages over Diesel: it has a high energy value: 50 MJ/kg (diesel: 30 MJ/kg); lower

[3] The Erneuerbare Energie Gesetz provides the frame work for the financial support for sustainable energy production. The costs are socialised, each company (except the ones with exemption) and household pay an annual fee.

[4] *Stimulering Duurzame Energie* is the main instrument to stimulate the production of sustainable energy.

emission of fine particles than diesel; gives less motor noise and is cheaper. LNG is liquefied natural gas, through lowering the temperature (-162^{0}C) . LNG made from biogas is purer CH_4 than LNG from natural gas, the fraction of longer CH molecules like ethane, propane, butane, pentane, hexane is smaller. The Green LNG (also called bio LNG or LBG) may be a good conversion route for biogas.

These aspects may provide opportunities for new developments.

2.5..3 Sustainable Supply Chain Manager

To support new developments a software tool called Sustainable Supply Chain Manager has been developed as a "deliverable" of the Interreg NSR IVA project Groen Gas/ Grünes Gas D-NL by the Carl von Ossietzky Universität of Oldenburg. Three cases were used to validate the tool: the case *Gemeinde Dornum* (D), the case *Gemeinde Westerstede* (D) and the case *Energy-Transition-Park in Coevorden* (NL).

The SSCM model is split in five different stages, which represents different working steps in the supply chains of the biogas plant. Stage 1 stands for the material supply value. Stage 2 for each part of the logistic needed to feed the biogas power plant with substrate or take the digestate back to the fields. Stage 3 shows the operating figures of the production. Stage 4 is reserved for the grid distribution and stage 5 for the usage of the biogas energy. The last stage is called A*ctions* and there the user can enter different models in terms of sustainability.

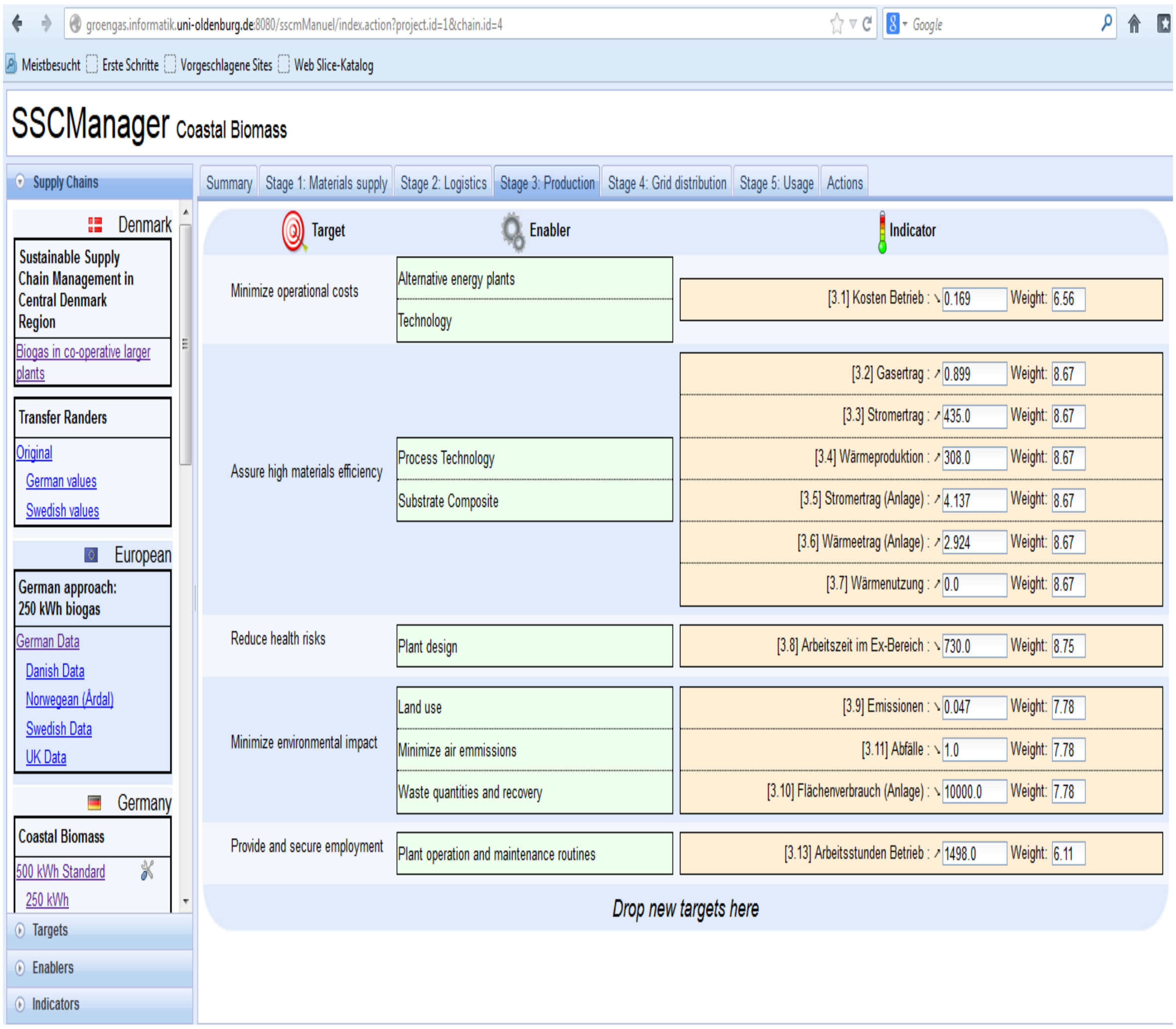

Illustration 10: Screenshot of the SSCM tool: Stage 3

The collected data are assigned to a model called “base chain”. This can be used to compare alternatives and to find the most sustainable solution based on the assessment the user decides for. By asking the preferences of people in area the social acceptance can be raised, the people in the area will be able to add their opinions about the importance (in the model the term is *weight*) of key figures.

The SSCM software tool simulates and enables the development of digester configurations with the highest sustainability (also economic sustainability) and acceptance with the help of the importance (weight) of the different indicators (or key figures) selected by the questionnaires. The indicators can be changed to provide a tailor made tool for the user.

These changes represent modified operational procedures in the supply chain of the digester and will be simulated with the help of the questionnaires and Promethee multi-criteria decision-making algorisms (MCDA). These create a ranking graph on the different digester models and their different specifications, to show the user, which changes will provide a sustainable solution under the decisions made previously.

MCDA is a discipline of operations research that explicitly considers multiple criteria in decision-making environments. Whether in our daily lives or in professional settings, there are typically multiple conflicting criteria that need to be evaluated in making decisions. This will help us to understand the complexity of the developments in the field of sustainable energy.

3. Energy Transition Parks - The case in Coevorden

One of the policy themes in the Northern provinces of the Netherlands is the development of energy transition parks. The policy is based on the presumption that different methods of energy production can be organised in synergetic combinations in which energy of different levels of exergy and materials can be exchanged and brought to value.

In Coevorden the local government, together with the Province of Drenthe, wants to stimulate these synergetic combinations. The following case is an example of promising co-development. The parties involved develop a concept that is different from the standard concepts: not small but large; not farm based but on industrial scale; not stand alone but with intensive interactions with neighbouring activities; not producing biogas ánd trading in input and output materials – but concentrate on biogas production; looking for the highest added value.

A German investor (hereunder called A) wants to use the experience and knowledge of the German fermenter industry and develop a fermenter on an industrial scale on the Dutch side of the German-Dutch location *Europar*k. The biomass input is mainly manure from the agriculture industry in the Netherlands (0,5 milion tons) and an additional input of maize (0,1 million tons). After the fermentation the digestate will be separated into a solid fraction and a liquid fraction. The solid fraction is then dried, this will be exported as a (P rich) fertilizer, the liquid fraction will also be used as a (N rich) fertilizer. The biogas is upgraded to natural gas standards and injected in the German gas system, with support from the EEG arrangements.

In this configuration the system needs an external source for the heating of the fermenters and the digestate drying process. A nearby wood pellet plant, with a surplus of heat, is able to provide the heat.

Company A. does not want to get involved in the logistics of input and output materials, he outsources this completely to a third party that brings in the biomass and looks after the digestate fractions, without charging costs.

The large amount of biogas (40 miljoen m^3) attracts the attention of a company (hereunder called B) that wants to develop a large scale bio LNG plant. The bio LNG will be delivered to the market by truck. Company B. calculated that a viable business case can only be developed if the biogas volume is 100 million m^3. A and B get into contact with another company (herunder called C) that is also preparing the development of a large scale fermenter in Coevorden. A and C together can produce 80 million m^3, this is enough for B to start a project.

For A and C the benefit of the tri partite configuration is that they do not need to invest in the unit for upgrading the biogas and in the unit for pumping the gas into the grid. Delivering the gas to the LNG plant can be done without subsidy, so there is no subsidy dependency.

The case with A, B and C is promising, but the “triangle” also has its dilemma’s: The LNG producer B wants to be sure that both A and C will start their production; but A and C wait until they are sure that B will start. The positions are not equal: B cannot go ahead without A and B, but A and C can go ahead with their fall back scenario’s: individual green gas production. To prevent stagnation because of the complex dependencies between the three, A. starts with the scenario of producing green gas and pumping it in the local Dutch gas grid, supported with SDE subsidy, with the intention to sell the gas to B. once B. is ready for it. B. starts with a scenario that his plant is not based on direct delivery of biogas from A and C. but on a certified volume of green gas, with the physical input of naturel gas. In a later stage the virtual green gas delivery can be changed into a “real”, direct delivery of the biogas.

The total complex will be able to convert approx. 1.2 million tons of biomass into fertiliser for agriculture, produce approx. 40 million kg of bio LNG (about 2 PJ) and approx. 20 million kg of “green” CO_2. The total investments will be around €120 million.

This project would not be possible without his intensive cooperation between the three main parties. New approaches and synergetic combinations can create large steps forward on the road of energy transition.

The material from this case is used to support the further development of the SSCM tool.

4. Outlook

The future of the biogas power plants is non-specific. The *Energie Wende* gives Germany and Netherlands the chance to build their sustainable energy infrastructure. Both countries have different laws and policies to reach their goals, but more and more the countries will need to integrate their policies; energy production and distribution is a cross border activity.

In the Interreg NSR IVA project Groen Gas/ Grünes Gas D-NL the partners try to learn from each other’s successes and failures. The SSCM will be a tool to model digesters in both countries and to compare them with each other under the weights set before by the user of this software tool. With new projects the SSCM can be developed further, also for other research fields in which supply chains need to be compared for their sustainability.

References

[1] Entwicklung der erneuerbaren Energien in Deutschland im Jahr 2011 Grafiken und Tabellen, Stand: Juli 2012 unter Verwendung aktueller Daten der Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat).

[2] Hernieuwbare Energie in Nederland 2011, Centraal Bureau Statistiek.