POSITIVE VIBE[R]S FOR PARKSTAD

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ABSTRACT

This paper gives an insight in strategies for implementing, processing and producing Miscanthus x Giganteus, or Elephant grass as it is mistakenly called, on a mid-large scale in the Parkstad Region. The area is rooted in agriculture because of fertile löss soil. There have always been was a tight bond between the villages and surrounding land. This connection was distorted when mining started in the late nineteenth century. The miners coming from everywhere were housed around the mines. The region thrived, until the mining industry stopped in the 60's-70's. Massive unemployment followed. Now fifty years after the closing of the mines Parkstad is still dealing with the consequences of a monoculture. Parkstad has accepted the shrinking as status quo and is now looking for new perspectives with a diverse sustainable economy. Miscanthus x Giganteus, a so called C4 grass, has made a march in the Western world in the last few years. The high yields need little maintenance, while it feeds on the abundant CO_2 coming from the fossil fuel industry. The plant, like the floating houses in Iraq, can be used as simple and effective building material. However the western world's interest in lignocellulosic biomass lied until recently primarily in creating biofuels like bioethanol. Due to new insights in biorefinery, the potential for Miscanthus x Giganteus seems much larger. Lignin a substance of the Miscanthus x Giganteus is for instance likely to be a building block for carbon fiber and currently in R&D stage. Once this is sorted out, it could provide in the need for reducing CO_2 emissions by making lightweight cars. Of the large area in Parkstad, grassland with 5000 Ha seems most appropriate for growing Miscanthus x Giganteus. Grassland has a low CO_2 intake of only 3-4 tons per Ha and there is plenty unused grassland in and outside the urban area, like Industrial plots, empty urban plots or alongside highways. However the majority of grassland is dedicated for livestock. But it will become more and more available since livestock will shrink eventually do to emission legislation and farmers needing to find ways to make their land profitable. Via a grid, pixels of 1ha, just like on your screen, can be turned on and off to spread the impact of the Miscanthus x Giganteus in the entire region. This will work as a large time machine that harvests CO_2 from the air and brings a sense of eternity to the people of Parkstad.

KEYWORDS: *Miscanthus x Giganteus, Parkstad, CO2, Biorefinery, Carbon Fiber*

I. INTRODUCTION

Parkstad is a conglomerate of eight municipalities in the South of Limburg covering 211km2. From 1899 to 1975 Parkstad had a thriving coal mining history, which lead to a blossoming region. For instance Heerlen, being one of the eight, grew from 6.000 in 1900 to 75.000 in 1975 (Heerlen.nl, 2018). But after the closing of the mines, 1965-1974, a mere 80.000 'Koempels or mine workers, were suddenly unemployed. This lead to a rapid decay of the area. Despite measurements of the government to place institutions like the CBS, with rather intellectual work. Which of course could not help the miner who was used doing heavy manual labor (Dohmen, J., 1999). From being one of the richest areas in the Netherlands in the fifties, the region rapidly dropped to the bottom of the list. Unemployment, low education and an ageing population are to date present in the area (CBS,2018).

Not only were the miners' jobs taken, they were also deprived of their history. Immediately after the closing of the mines, the motto '*From black to green'* was introduced and everything related to the mine industry was torn down and subsequently replaced by greenery. Currently Parkstad is looking

for new economic models, that are based on three pillars: tourism, health, care & cure and new energy. (Parkstad Limburg, 2007) .

II. CHANGING LANDSCAPE

A landscape is always changing. Elements like the wind or water, but also flaura and fauna are constant factors influencing the environment. And then there is of course mankind. Sometimes changes are gradual but every now and then there is a massive interruption. The mining industry that landed in Parkstad was sudden, fierce and came to an abrupt end. The region is fifty years later still dealing with the consequences.

2.1. A Brief History

The plant rests that later turned into coal, were formed around 300 million years ago in the Carboon Wesselinck, F., et al 2018). During that period an abundance of CO_2 was in the atmosphere enabling together with a tropical climate massive plant growth. Much later, during extreme cold periods in the Weichselein a mere 100.000 years ago, winds from the west blew fertile soil from the barren Northsea bed to the South of Limburg (Kokshoorn, M., 2018). This soil type is called Löss and is a nutrient top-layer, suited for agriculture. This was also noticed by the Romans who settled here from 0-400 AD in a town called Coriovallum. Later, on the remains of the Roman settlements, a small agricultural town arose in 1065 with the name Heerle, flanked by other small villages, castles and farmsteads. In 1850 the town of Heerlen consisted of still no more than 6.000 people and was an isolated village with still agriculture as a main resource (Heerlen.nl, 2018). Due to the Industrialization, mostly driven by steam engines, a growing demand for coal arose from 1850 onwards. The South of Limburg was known for containing coals and small scale mining. But poor infrastructure and high water levels prevented further exploitation (De mijnen, 2018). These issues were resolved with a new train line in 1896 to Heerlen and pumping systems based on steam engines. This lead to a large industrial area with factories and waste mountains having a huge impact on the landscape. Eleven mines appeared in the current Parkstad area where in total 471 billion of coals were mined (De mijnen, 2018). With the mines came employees, their family and thus houses, infrastructure and amenities. These were clustered around the mines and only partly succeeded in merging with the existing villages, resulting in a fragmented area with a multitude of cores. (https://erfgoedenruimte.nl/nieuw-perspectief-voor-parkstad). After the closing of the mines in 1965-1974, the coal mines were dismantled and almost all coal related buildings and minestone piles were removed, leaving empty spaces in a now unreadable urban fabric. All of sudden a mere 80.000 people lost their jobs (Dohmen, J., 1999). From the respected and hardworking mineworkers they had turned all of a sudden into low-educated jobseekers with little prospects. Government spent a fortune to keep the region alive, for instance by allocating institutions like CBS to the region. But a pride koempel (miners) sitting behind a desk was a bad combination (Elzerman, K., Bontje, M., 2015). High crime rates, unemployment of 25% and drug addiction lead to a rapid decline of the area. Being once on top of the high income list in the fifties, in the seventies the mine cities dropped to the bottom. Shrinkage of the population set in due to little economic prospects, low birthrates, high death rates and students leaving the region and not returning (Elzerman, K., Bontje, M., 2015).

2.2. Current Status

Only 43 years after the closing of the mines, it is hard to imagine that Parkstad was a flourishing mine region. The slogan *'From black to green'*, has indeed had its effect. Most mining sites are now covered with green and act as parks. For instance the Wilhelmina mine, where a ski track is positioned on the flanks of the former minestone hill. The map of the region shows indeed many green spaces in and around the urban area and the name Parkstad is in that sense well chosen. Parkstad still is shrinking but not as hard as was expected, this is mainly due to newcomers (1Limburg, 2017). There has been attempts to demolish the old mineworkers houses. But they form a tight community and are attached to their homes. (Tegenlicht, 2011). There is still low employment rates and the people are low educated (CBS, 2016). There is currently a longing of recognition for the miners and what they have achieved. The industrial revolution and thus were we stand today as society could not exist without the coals from Parkstad. The radical attempt to wipe out a history has

been a short sided one. But dealing with mine history and the consequences goes both ways. Parkstad is now dealing with pollution from the minestones (Satijn, H., 2002).) or instable ground caused by collapsing mineshafts. And on a bigger scale the amount of CO_2 in the atmosphere caused by coal burning is enormous, since for every gram of coal, 2.86 grams of CO_2 is released in the atmosphere (Hong, B., & Slatick, E., 1994).

2.3. New Horizons

The most important thing to do for a region confronted with shrinkage is to face it and to act upon it. (Elzerman, K., Bontje, M., 2015). The natural reaction from politicians and local government is to see shrinkage as a temporarily state, since we are so inclined thinking in terms of growth. Parkstad has accepted the situation fully and is now looking for new possibilities and they are trying to see shrink as an opportunity. With the introduction of IBA in 2013, an institution normally exclusively German, a start off has been made with looking for new projects and thus horizons for Parkstad. That can either be large scale or small interventions. For instance a leisure bike lane that connects most green areas, parks and special sights (IBA Parkstad, 2018) The key thing is to look for a diverse and thus sustainable landscape (Elzerman, K., Bontje, M., 2015). Thinking long term is rather important for this region that has experienced the negative consequences of a single and limited layer as the mine industry, that when falling apart will be very hard to replace. (Parkstad Limburg 2007). However Parkstad lack a surplus of entrepreneurs (Elzerman, K., Bontje, M., 2015). It is not in their genes so to say. But at the same time they dislike governmental influences. To create new incentives for the region has to be done with collaboration and approval of the local community.

III. POWER PLANT

One of those solutions might be Miscanthus x Giganteus, mistakenly called Elephant grass. Recently in the news (NOS, 2018), it seems a super plant which can solve a lot of our current problems like harvesting CO_2, solving energy deficits (bio-ethanol) and replace plastic waste streams by compostable bioplastics (link). It might be a solution for a shrinking city, where space and labor are as a result available. But can the Miscanthus grow in Parkstad and to what ends can it be used?

3.1. Growing

Miscanthus x Giganteus (MxG) is a sterile hybrid between Miscanthus Sinensis and Miscanthus Sacchariflorus. The plant is a C4 grass, meaning that it uses an extra step in the photosynthetic process making a connection with four carbon atoms, hence the name C4. C4 grasses normally do not occur in Europe. The total absorption can lead up to 40t/ha of CO_2, of which one halve will stay in the ground (Navard, P., 2016). The seeds of the plant are sterile, it only propagates via rhizomes, a root that multiplies a factor of 15 in 4 year. Therefore a crop planted in year 0 will produce approximately 150,000 rhizomes per hectare by year 4. Planting the regenerated rhizomes at a rate of 15,000 per hectare should provide enough rhizomes to plant another 10 hectares (Caslin, B. et al, 2011) . The total lifecycle of a rhizome is around 20 years. The first two years yields of the MxG crops are rather low and only then fertilizer is needed. In the third year the plant reaches its maximum height of around 4 meters high.

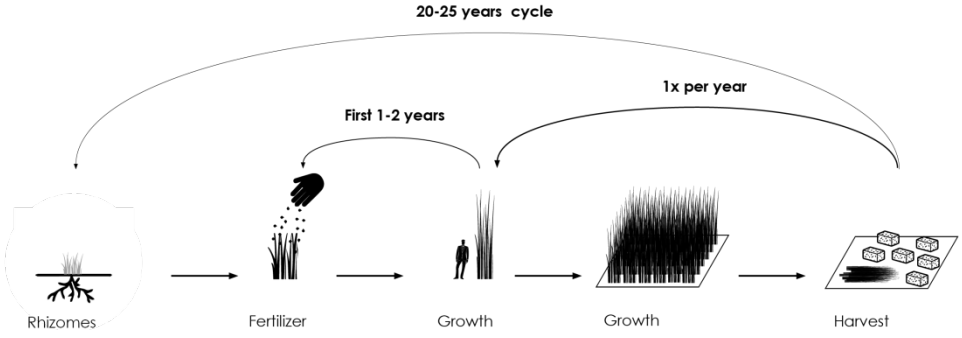

Figure 1: Growth cycle Miscanthus x Giganteus

And thus total yields can grow up to 20 tonnes of dry material per hectare. According to this data, if you use 1 ha for rhizomes growing, you end up with around 100 ha of MxG after 20 years, leading up to a mere 170 tonnes of MxG. This is also the maximum amount, since rhizomes have a lifecycle of around 20 years (figure 1).

MxG is a resilient, meaning it can grow on many soil types. As long as there is a minimum of 600-700 mm of rainfall. Furthermore the photosynthesis of MxG stops at 6 Celsius. Both are within the margins of Parkstad (Climate-data.org). There is disagreement of what is the best time to harvest For instance harvest in October produces most material, because the leaves have not fallen of yet. But when harvesting in April, the soil needs less nutrition and the stems contain less moisture. Harvesting is done with a baling machine or a chipper. In order to become economical viable areas should be at least 2 ha and ground should be available for a least 6 years. An extra bonus of the crop is the contribution to biodiversity in comparison with winter sown cereal crops (Nixon, P., Bullard, M. 2001). Due to the dense bushes, species like worms, spiders, mammals and birds seem to thrive there. Important to realize is the use of grass headlands around the crop, to prevent shading to existing habitat (Caslin, B., et al, 2011). MxG also filters air and works sound absorbing.

3.2. Processing

Once the MxG is harvested the question rises what to do with it? And who will do it? Of course there is the possibility to treat the MxG in its original shape, thus without processing, as simple but rather effective building material. In certain warm parts in the world like Iraq, floating houses are made within days from MxG. (Messy Nessy Chic,2018) Closer to home there are several ways to apply reed MxG, like using the bales as building blocks, as insulation or as fiberboard (Dam van, J., & Oever van, M., 2012). Also there are multiple ways to apply MxG in concrete. Applying up to 0.25% of fibers of the MxG leaves adds to the strength of concrete (Ezechiels, J., 2016). (link) But it can also act as plastifier or even as aggregate in concrete. This kind of low to mid-tech fabrication suits, according to the education stats, Parkstad well.

In recent years the perspective on biomass has changed however. This is part of the circular economy and the awareness of a post fossil fuel world (Hoeven van der D., Reinshagen, P., 2013). The MxG belonging to the lignocellulosic biomass, contains around 20% lignin, 40-45 % cellulose and 20-30% hemicellulose, all with different properties. There are several processes or conversion methods for dealing with a lignocellulosic biomass. For instance the paper industry uses for 80% the kraft method. This is a mechanical (heat and steam) and chemical (sulfate) process. Only the cellulose and hemicellulose are eventually used for paper. The lignin in this case has no real purpose other than to use it as heath source. Also should be noted that the structure of the lignin in this process has altered (Bruijnincx, P., et al, 2016).

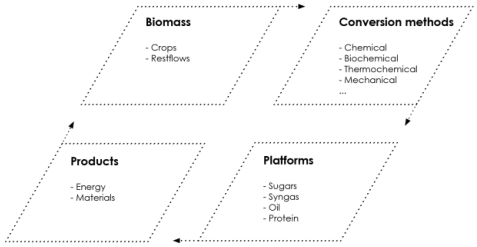

Figure 2: Scheme for *Biorefinery.*

However working with heat, steam or pressure does not really fit in the new paradigm of a green, circular and post-fuel society, while it uses a lot of energy and CO_2 emissions. Fermentation, working biomechanically with enzymes and bacteria, does. But this process is hard to control and still in research phase for industrial applications (Suhag, M., Singh, J., 2014). This green thinking will also lead to a different 'silhouette', a new kind of architecture without the pipes (Hoeven van der D., Reinshagen, P., 2013). But working with biomasses and fermentation processes is not completely without risk, think of heating of corn in silos or toxic forming. Also there is an upper limited of 100-200 m3 per reactor vessel to control the fermentation. A successful factory will not be dependent on good infrastructure or entirely on scholar knowledge but mostly on highly skilled workers.

3.3 Producing

Currently there is a lot of research about how and what to make from biomasses. New refineries and test facilities are popping up throughout Europe. America wanting to be energy independent is mainly looking for energy. In Europe the focus lies predominantly with adding value. Here is a direct relation between quantity and quality (Hoeven van der D., Reinshagen, P., 2013).

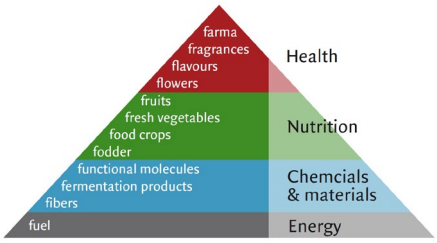

Figure 3: The value pyramid of green materials, Hoeven van der D., Reinshagen, P., 2013

Producing energy out of biomass is considered the lowest value in the pyramid. But it should not be kept completely out of sight. Bioethanol is needed for tractors or airplanes since they cannot use batteries yet (Koenen, J., 2017). Lignin for instance turns out to be a building block with much more potential. The key here is how to extract it, because one has to deal with a fluctuating composition when dealing with natural material. It is therefore much more complex than the oil based industry, which also has 50 years more experience. Another difference between the oil and bio industry is that the oil industry is clustered whilst it is dependent of each other on both materials and energy (Hoeven van der D., Reinshagen, P., 2013). Chemelot in Limburg houses many intertwined oil based companies. The bio industry is regional and more efficient. But in change they have to work with the agricultural sector since they are the providers of the flows. Therefore the agricultural sector will have more influence and get richer.

One of the more appealing options is to make a precursor of carbon fibre out of lignin. It turns out that there are at least two consortiums, sponsored by the EU, currently working on this topic namely Greenlight and Libre2020 (Bio-based industries 2018). The challenge lies in gaining lignin by a conversion process (technical lignin) that is strong and with long carbon chains (Bruijnincx, P., et al, 2016). To produce high tech carbon fiber out of a product that was considered useless is of course the holy grail. Especially since demand for carbon fiber is increasing each year. (Mainka, H., et al, 2015). In car industry, mass application of carbon fiber will have a huge impact on the total weight of the car and thus on the amount of CO_2 emissions.

IV. Strategies for Implementation

So on what scale can MxG be grown in Parkstad? Parkstad is quite a large area, but of course there are only certain parts where it can grow. Can the grass be used for double purpose, for instance as

soundbarrier? And what kind of impact has a grass of 4m high on the landscape? Can and will the people from Parkstad accept this stranger in their midst ?

4.1. Grassland

Since Parkstad is such a large area with 200km2, water excluded, it is maybe better to determine where MxG can't grow, Obviously it should not be at the expense of growing food since MxG as energy or fiber supplier has lower value. That leaves already 5700 ha of agriculture out of the equation. Then there is the urban fabric, with all the privately owned plots that is good for another 5000 ha. Considering touristic value, forests (2800ha) and heather (200ha) can also be taken out. The large remaining part with 5040 ha is then grassland. Grassland only absorbs 3 to 4 t/ha compared with agriculture (4 to 6 t/ha) and woodland (>6 t/ha).

The grassland can be categorized in 4 domains: land for livestock, unused land in the industrial areas, grass strips around infrastructure and unused grassplots inside the urban fabric. Most grass land is positioned outside the urban area, either in the West or North of Parkstad. This land is predominantly meant for livestock. The South of Limburg has an extensive livestock in contrast to the North of Limburg, meaning that farms are relatively small (Baltussen, W., et al, 2010). In the future livestock might even get smaller, due to upcoming legislation since livestock produces methane (Hotse Smit, P., 2018). And methane's (CH4) effect on heating the atmosphere is 25 times larger than CO2. According to an article in the nineties there have been attempts with growing non-eatable crops or 'agrification' as it was called, instigated by the government (Bos, H., et al 2008). Although not considered a success in the beginning, it eventually led to several spinoffs for instance growing flax for the car industry. The main issue here was to manage expectations while technical progress was very slow, more than a decade.

The empty grass areas inside the many industrial areas could be a potential place for growing MxG. The industrial areas are all located along highways and either in or outside the urban area. Zoomed in on all of them, there is actually a decent amount of grassland between the buildings. Considering the fact shrinkage has set in (Elzerman, K., Bontje, M., 2015), it is unlikely these plots are filled in overnight. Since MxG needs at least 6 years to be profitable (link), it would be a business opportunity for the owners earning money. There is also little touristic value, besides a planned leisure road that crosses Dentgentbach in Kerkrade. (IBA Parkstad 2018).

There is quite some infrastructure in and around Parkstad. With the highway A76, N281 and the ring N300 and of course a train track. MxG is scientifically proven to be both a sound absorber and airfilter (link), so this could be a nice combination. But it should be noted that MxG is a natural product and only starts growing in spring, so it is not a permanent barrier. Also the appreciation of the landscape is mostly done by car, thus blocking the view with a 4m high wall is not wanted. Where MxG definitely could be of help is along the N281. There have been requests to decrease speed limit to 80 instead of 100 km/h. These strips of grass are however occasionally small and irregular and might not be suitable for easy harvesting.

Lastly the grass fields within Parkstad itself. Some of these areas are assigned as parks, others are not. For instance a plot of 5ha in front of the CBS building is waiting for anything to happen, which is now used for walking the dog. There is also grassland on the former mine areas and. There is an IBA project (link) that proposes to grow forests around neighborhoods. From a CO_2 and biomass perspective this could be altered into a MxG forest. With all ideas about filling in empty places within urban fabric, social implications should be noted. The grass grows dense and is 4 m meters high. This could lead to feelings of unsafety. But on the other hand, empty spaces are also not desired (Bjerke, T., et al. (2006) and people like moderate dense scenes most. A good example of how to deal with MxG and public space is the park near Schloss Dyck by RMP Landschaftsarchitecten (Landezine 2009). The MxG is placed in a playful grid. Between the dense crops lie broad strokes of grass and a pavement.

4.2. Design vs indiscriminate placing

Is there design to a 'standard' field of crops? Yes of course there is design, because there are thoughts on how and where the crop should be placed. In chapter 2.1 is described how by using one hectare after 20 years around 100 ha of MxG can be produced. What are the thoughts of placing this amount of MxG. If this amount was bundled, it will be hard to find an area of that size and will have a huge impact on the landscape. The tiniest amount of growing MxG and making it economical viable is a minimum of 1 or 2ha. An example of how to spread the 100 ha could be 'Umbrellas' project by Christo (Christo, 1988). They placed 3.100 bright colored umbrellas in a valley in both California and Japan at random places in the landscape. Considering the MxG crop as a pixel of 100 by 100 meters, they can be distributed over Parkstad according to a grid. Then at random, pixels can be turned off or on, considering the need for MxG. In that way the load (implications and CO_2 intake) will be spread evenly over a long period of time. This is in agreement with the long term goals of Parkstad.

4.3 Co-operation

The questions are who owns the land on which MxG grows on and what to do with it? In 4.1 the four domains where grass is grown result in 3 parties: the farmer on the land, the municipality in the urban area and the private corporation on the industrial site. They both might have different interests but key here is bringing them together. Especially the agriculture sector, who will in the post fossil fuel era will become more dominant in the debate but are not used to communication and market processes (Hoeven van der D., Reinshagen, P., 2013).

The urban area will deliver the works force, which will be mostly low tech with fits their background , but also some skilled workers for fermentation processes. (Hoeven van der D., Reinshagen, P., 2013). The industry will deliver of course the market knowledge and the agricultural sector brings mostly land and machinery. In a scenario of 100 ha, dedicated for MxG growth, a 170 tons can produced annually. This could be quite a business case for making either low tech products, paper, bioplastics or eventually the lignin based carbon fiber process.

4.4. Perceived beauty

The big question is will the people from Parkstad accept this newcomer? Already mentioned in 2.2 that they distrust large institutions like state and church (Elzerman, K., Bontje, M., 2015). But at the same time they in general lack the skills to create incentives themselves. On first sight MxG seems odd to this landscape. For instance choosing for winefields might be more obvious, since there is an early connection with the Romans (Wikipedia, 2017) and indeed winemaking is growing in the Netherlands. But quality is in general lacking and there is already an abundance of wine worldwide. (Heijboer, E., & Goot van der, E., (2014)). On a deeper level implementation of MxG might fit very well in this landscape. If we think in large cycles, where did the coal from in the first place? From plants of course. By slowly overtime harvesting the CO_2, using one part, to create for instance lightweight vehicles and leave another part in the ground, the cycle can be closed.

V. CONCLUSIONS

The Parkstad region has a region rooted in a history of agriculture, due to fertile soils. The mining industry has abruptly disturbed this relation with a relative short term digging for coals. The landscape changed drastically. After the closing of the mines everything was greenwashed. But the falling away of a mono-functional industry lead to all kinds of problems, as shrinkage and low employment. On a larger scale the CO2 pollution caused by burning the coals is also not something to be proud of. Parkstad has accepted it's position of a shrinking region and is now looking for diverse sustainable potential. Key is to understand the role the former miners dependency on and mistrust in large institutions like national government or church. New initiative should be positive for the long term and not enforced.

Implementing Miscanthus x Giganteus, a C4 grass that grows rapidly whilst absorbing 20 times more CO_2 than a forest, seems possible in Parkstad. MxG is an infertile grass, that grows out of rhizomes. With 1 ha of ground one can grow up to 100 ha in 20 years. Then the maximum is reached since the

rhizomes lifecycle ends after 20 years. All circumstances like soil type, water and sunshine are present and it needs little maintenance. The application of MxG is plentiful, ranging from low to high tech. It can be used without too much treatment in simple building material. This kind of manual processing would fit the background of the people in Parkstad. Originally the MxG was meant for biofuel, like bio ethanol. Although this is still possible, the realization came that using sun or wind as power source is much more efficient. To process MxG, a lignocellulosic biomass, there are several options. The kraft pulp process is most common in the paper industry. With steam and sulfate they manage to divide the substance into paper pulp and lignin. The challenge is to extract, the lignin, cellulose and hemicellulose without too much damaging and energy. A better understanding of working with nature would be the fermentation process. Working with bacteria and enzymes is however a difficult and custom process. Skilled workers and more knowledge is needed. Primarily because perennial grasses are each time different due to fluctuating weather conditions. The real potential and value for MxG lies in fibers or aromas made out of lignin. Currently there are at least two consortiums (subsidized by the EU) working on how to make precursor, the building block for carbon fiber, out of lignin. This would provide in the growing need for lightweight vehicles.

In all of these processes and innovations it is important to understand that they take time and expectations need to be managed. Communication is vital in this process. Especially for the regional agriculture sector, since the international petrochemical industry, a world of dependency and clustered factories will slowly disappear. The new supplier of products will be the agricultural sector working together with the chemical world. In the case of Parkstad, there lies an opportunity for the agricultural sector to look for new opportunities working together with the industrial sector which is already present and create employment.

Looking at the large area of Parkstad the option to choose for grassland is most logic. Roughly a quarter (5040ha) of Parkstad is currently grassland. There are 4 distinct types of grassland, of which land for livestock and owned by farmers is by far the largest. Due to upcoming legislation the amount of livestock will shrink. They will therefor play a vital role in the scale of the MxG production. Insight the urban fabric and industrial sites there are plenty unused plots and also alongside large infrastructure. On these places there is enough space to grow MxG. With the yields local entrepreneurs can start a factory for low tech materials. If all land is made available, a random pixel selector can operate via a grid to point out certain areas. On these sites of 1ha MxG can start growing and after 20 years the site is reclaimed leaving a carbon mark in the ground.

Since the growing process of the MxG area is gradual, the people of Parkstad might slowly start getting used to the newcomer. In fact they will understand that the newcomer is the very same material their father and grandfather have found, hidden deep under the soils of Parkstad. It will be a positive contribution to the CO_2 dilemma as well as a provider of jobs.

REFERENCES

1. Annevelink , B., Harmsen, P. (2010). *Bioraffinage. Naar een optimale verwaarding van biomassa.* Wageningen: Propress.
2. Annevelink, E, et.al. (2013), *Logistiek Biobased Economy: toekomstbeelden 2025 & agenda 2013-2017.* Wageningen: UR Food & Biobased Research
3. Baltussen, W., et al, (2010). *Duurzame ontwikkeling van de veehouderij in Limburg*. Den Haag, Alterra
4. Bio-based industries. (2018). *Bio-based Industries.* [Online]. Available at: https://www.bbi-europe.eu/projects [Accessed 4 Jan. 2019].
5. Bos, H., et al (2008). *Agrificatie en de Biobased Economy - Een analyse van 25 jaar beleid en innovatie op het gebied van Groene Grondstoffen.* Wageningen
6. Bruijnincx, P., et al, (2016). *Lignin valorisation, The importance of a full value chain approach.* Utrecht
7. Bjerke, T., et al. (2006). *Vegetation density of urban parks and perceived appropriateness for recreation.* Lillehammer, Urban Forestry & Urban Greening 5
8. Caslin, B., et al, (2011). *Miscanthus best practice guidelines.* Hillsborough, AFBI,Northern Ireland.

9. CBS. (2018). *CBS Statline.* [online] Available at: https://opendata.cbs.nl/statline/#/CBS/nl/ [Accessed 4 Jan. 2019].
10. Climate Data. (2018). *Climate-Data.org.* [online] En.climate-data.org. Available at: https://en.climate-data.org/search/?q=heerlen [Accessed 4 Jan. 2019].
11. Christo, J., Christo, C., (1985). *Projects | The Umbrellas.* [online] Available at: https://christojeanneclaude.net/projects/the-umbrellas [Accessed 4 Jan. 2019].
12. Dam van, J., et al., (2016). *Lignine Groene grondstof voor chemicaliën en materialen.* Wageningen Food & Biobased Research
13. Dam van, J., & Oever van, M., (2012). Catalogus biobased materialen, het groene bouwen. Propress, Wageningen
14. De Mijnen. (2018). *Van groen naar zwart, en weer terug.* [online] Available at: http://www.demijnen.nl/van-groen-naar-zwart-en-weer-terug [Accessed 4 Jan. 2019].
15. Dohmen, J., (1999) *Trots Heerlen werd zielloze stad.* NRC
16. Elzerman, K., Bontje, M., (2015). *Urban Shrinkage in Parkstad Limburg, European Planning Studies, 23:1, 87-103*, DOI
17. Ezechiels, J., (2016). *Design of an innovative bio-concrete using Miscanthus fibres*. Eindhoven, Tu Eindhoven
18. Heerlen.nl. (2018). *Geschiedenis van Heerlen.* [online] Available at: https://www.heerlen.nl/gemeente-heerlen/geschiedenis-van-heerlen.html [Accessed 4 Jan. 2019].
19. Heijboer, E., & Goot van der, E., (2014) *Nederlandse wijn wordt nooit concurrentie voor 'echte wijnlanden'* [Online]. Available at: https://www.nu.nl/weekend/3807989/nederlandse-wijn-wordt-nooit-concurrentie-echte-wijnlanden.html [Accessed 4 Jan. 2019].
20. Hoeven van der D., Reinshagen, P., (2013). *Strategieën voor een groene samenleving.* Biobased society-eu.
21. Hong, B., & Slatick, E., (1994). *Carbon dioxide emission factors for coal* [Online]. Available at: https://www.eia.gov/coal/production/quarterly/co2_article/co2.html (Accessed: 4 January, 2019)
22. Hotse Smit, P., (2018). *https://www.volkskrant.nl/nieuws-achtergrond/nederlandse-veestapel-moet-fors-krimpen-om-klimaatdoelen-parijs-te-halen-adviseert-raad-en-snel-ook~b239ec79/*.Volkskrant
23. IBA Parkstad. (2018). *Leisure Ring & Leisure Lane - IBA Parkstad.* [online] Available at: https://www.iba-parkstad.nl/projecten/leisure-lane/ [Accessed 4 Jan. 2019].
24. Kasper, G., et al. (2017). *Samenstelling blad, stengel en rhizomen in relatie tot optimaal oogsttijdstip van Miscanthus x giganteus.* Wageningen Livestock Research, Rapport 1022
25. Kasper, G. (2012). *Literatuurstudie van Miscanthus gericht op warmte en elektriciteit op boerderijschaal.* Wageningen Livestock Research, Rapport 549
26. Koenen, J., (2017). The sky is the limit. [Online]. Available at: https://global.handelsblatt.com/companies/the-sky-is-the-limit-834712 [Accessed 4 Jan. 2019].
27. Landezine (2009). *Dyck Castle, RMP Landschaftarchitecten* [Online].Available at: http://www.landezine.com/index.php/2009/07/new-garden-dyck-castle/ [Accessed 4 Jan. 2019].
28. Mainka, H. et al (2015). *Lignin – an alternative precursor for sustainable and cost-effective automotive carbon fiber*. Elsevier
29. Messy Nessy Chic. (2018). *The Floating Basket Homes of Iraq: A Paradise Almost Lost to Saddam.* [online] Available at: https://www.messynessychic.com/2014/11/12/the-floating-basket-homes-of-iraq-a-paradise-almost-lost-to-saddam/). [Accessed 4 Jan. 2019].
30. Navard, P., (2016). *Treatments of plant biomass for cementitious building materials.* Elsevier
31. Nixon, P., Bullard, M. (2001). *Planting and growing Miscanthus*. London : Defra
32. Nl.wikipedia.org. (2018). *Weichselien.* [online] Available at: https://nl.wikipedia.org/wiki/Weichselien [Accessed 4 Jan. 2019].

33. Nos.nl. (2019). *Deze mensen denken dat dit 'superriet' de wereld gaat veranderen.* [online] Available at: https://nos.nl/op3/artikel/2249493-deze-mensen-denken-dat-dit-superriet-de-wereld-gaat-veranderen.html [Accessed 4 Jan. 2019].
34. Kokshoorn, M. (2018). Löss - Geologie van Nederland. [online] Geologievannederland.nl. Available at: http://www.geologievannederland.nl/landschap/landschapsvormen/loss [Accessed 4 Jan. 2019].
35. Parkstad Limburg, (2007). Kadernota Economie Regio Parkstad Limburg 2007-2010.
36. Robertson A., et al. (2017). *A Miscanthus plantation can be carbon neutral without increasing soil carbon stocks.* John Wiley & Sons Ltd.
37. Satijn, H. (2002). *Interactieve risicobenadering bodemproblematiek voormalige mijnstreek oostelijk Zuid-Limburg.* Gouda, Alterra
38. Suhag, M., Singh, J., (2014) *Recent Advances in Fermentation of Lignocellulosic Biomass Hydrolysate to Ethanol.* India
39. Steen van, J. (2010). *Potentiele hoogwaardige toepassingen van riet. Een marktverkenning.* Utrecht
40. Tegenlicht (2011). *Krimpen aan de Maas* [Online]. Available at: https://www.vpro.nl/programmas/tegenlicht/kijk/afleveringen/2010-2011/krimpen-aan-de-maas.html [Accessed 4 Jan. 2019].
41. Wesselink, F., et al. (2018). *Reconstructies tijdvakken - Geologie van Nederland. [online] Geologievannederland.nl.* Available at: http://www.geologievannederland.nl/tijd/reconstructies-tijdvakken/carboon [Accessed 4 Jan. 2019].
42. Wikipedia (2017). *Wijnbouw in Nederland*. [Online]. Available at: https://nl.wikipedia.org/wiki/Wijnbouw_in_Nederland. [Accessed 4 Jan. 2019].
43. 1Limburg. (2012). *GL wil snelheid stadsautoweg Heerlen omlaag.* [online] Available at: https://l1.nl/gl-wil-snelheid-stadsautoweg-heerlen-omlaag-52242 [Accessed 4 Jan. 2019].
44. 1Limburg. (2017). *Parkstad: weer afname van krimp.* [online] Available at: https://www.1limburg.nl/parkstad-weer-afname-van-krimp [Accessed 4 Jan. 2019].

Figure 1: Growth cycle Miscanthus x Giganteus
Figure 2: Scheme for Bioraffinage. Naar een optimale verwaarding van biomassa. Wageningen: Propress.
Figure 3: The value pyramid of green materials, Hoeven van der D., Reinshagen, P., 2013