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# SPACE FOR BIOMASS

An exploratory study of the spatial potential for the cultivation of biomass for energy in The Netherlands

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**Abstract**
The spatial and energy potential in The Netherlands for energy farming is assessed as well as for a number of biomass residues. The future supply of agricultural land is based on closures of farms. Various future claims for infrastructure and nature are taken into account. The net supply of land adds up to 100,000 - 185,000 in 2000 to 245,000 and a theoretical maximum of 465,000 ha in 2015. When this potential is used for energy crops like Miscanthus this land could contribute 20 - 37 PJ in 2000 and in 2015 62 - 117 PJ. Secondary yields of biomass can contribute a further 32 PJ in 2000, decreasing to approx. 24 PJ in 2015
This implies 2% of the Dutch energy demand in 2000, in 2015 about 3%, provided that energy farming is an economically feasible activity for farmers.

## 1. INTRODUCTION

The role of biomass as a 'renewable' source of energy is once again the centre of attention for a variety of reasons. Technological developments make it possible to achieve a far higher yield from the conversion of biomass into electricity or fuel than in the past. Developments in the agricultural industry, such as the predicted shedding of agricultural land, also play a role. A study conducted by the Scientific Scientific Council for Government Policy (WRR), entitled 'Ground for choices', outlines a number of scenarios for agricultural use of the land in the European Union depending on the agricultural policy currently in force. Agricultural land is released in each of the described scenarios (1). This land could, however, be used for the cultivation of crops suitable for energy production (energy cultivation). The available surface area is a decisive factor in determining the energy potential of biomass. If agricultural land falls vacant in the Netherlands, there will be several sectors lining up to use it, given the high population density. This has resulted in the formulation of the following question:
What is the spatial and energy potential of biomass production in the Netherlands in the long term (2000/2015), with or without other functions, seen together with other claims on the space?
This exploratory study focuses primarily on land that is not used for other types of agriculture (any longer). Energy cultivation on this land is possible, provided it is economically viable for agricultural industry (alongside food production). If, however, the yield of energy crops increases in the future, competition with food production may become possible. The spatial potential would then be on a quite different scale.

## 2. METHODOLOGY & RESULTS

### 2.1 The spatial potential: supply and demand for agricultural land

The supply of and demand for agricultural land are based on calculations made in the LEI (Agricultural Economic Institute) study 'Regional Land Balances'(2). The base calculation in the study shows a total supply of 280,000 hectares in the period 1990-2000. In a high supply scenario this surface is 410,000 hectares. This LEI study assumes that land that falls vacant comes from closures of farms. An average closure percentage and an average farm hectarage, which incorporate up-to-date developments in the sector, were used as a basis for estimating the total surface area of the land which will become vacant.

A large part of the available land is grassland with a milk quota. This study assumes that grassland with a milk quota will be used for the same purpose after it goes on offer. We have also assumed that the claims of the intensive livestock farming industry and horticulture (under glass) will be honoured, entailing approximately 8,000 hectares until the year 2000. The demand for non-agricultural land can be divided into 'hard' claims and other claims. Hard claims on land are laid by housing, industry, traffic and military training grounds. Other claims come from forestry, nature and recreation. An analysis of each of these functions has been carried out. Each function was studied to ascertain the expected spatial development and how this translates into a claim on land. A full description of the applied methods is given in (3).

Table 1 shows the spatial potential for energy cultivation in the year 2000 for the basic supply of 280,000 hectares and the variant with a higher supply of 410,000 hectares. The basic assumption is that the 'hard' claims will be honoured, and they have been deducted from the supply of agricultural land. This imposes an upper limit on the spatial potential.

Table 1 Spatial potential for energy farming on agricultural land in 2000, calculated as of 1990, in hectares (x 1,000).

| Land supply until 2000[1] | Hard agricultural claims[2] | Hard non-agricultural claims[3] | Other non-agricultural claims[4] | Spatial potential |
|---|---|---|---|---|
| Basic supply 280 | 105 | 24 | 53 | 100 - 150 |
| Higher supply 410 | 200 | | | 135 - 185 |

1 The supply of land in the LEI study was based on 1989. This figure is translated to the period as of 1990.
2 Claims from livestock farming (grassland with milk quota) and claims from intensive livestock farming and horticulture (under glass).
3 Claims from housing, industry, traffic and military training grounds. For calculation, see table 9.5.
4 Claims from forestry, nature and recreation.

The spread of the spatial potential depends on whether the other, non-agricultural claims will be honoured wholly, partially or not at all in the future. If all other non-agricultural claims are honoured, the lower limit on spatial potential will be reached. At a supply of 280,000 hectares, at least 100,000 hectares could be available for energy cultivation in 2000, up to a maximum of 150,000 hectares. For the year 2000, this estimate of the spatial potential according to the basic supply seems the most realistic. One must not forget that this potential is based on calculations as of 1990. No part of this potential had been realized by 1994.

For 2015, a linear extrapolation was made of the data in the LEI study for 2000. The different kinds of claims were then deducted. In 2015 between 245,000-375,000 hectares could be available at a supply of 28,000 hectares per year. According to the author of the LEI study, the linear extrapolation of the data for 2000 produced a conservative estimate of the basic supply in 2015 (4). The LEI study is an approximation at micro level (supply on farm level), and assumes implicitly that the land market wishes of every farmer will be honoured. Developments at macro level (agricultural production ceilings, for example) were not included in the study. This would have made it impossible to meet each individual farmer's wishes. Consequently, the supply after the year 2000 could be considerably higher than in the base calculations, while the claims remain the same. On the other hand, there are other agricultural developments underway (essential reductions in emissions of environmentally harmful substances, biological farming) which could lead to more extensive use of the land, producing in turn a lower supply after 2000 than envisaged in the basic calculations.

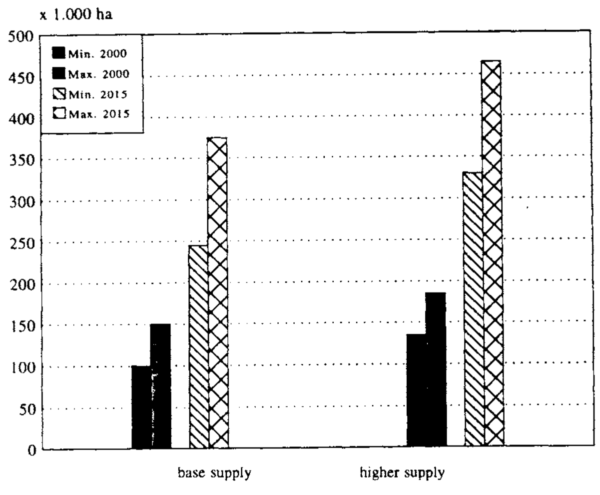


Figure 1. Spatial potential for energy cultivation on agricultural land in 2000 and 2015 for a basic supply (28,000 ha/yr) and a higher supply variant (41,000 ha/yr), as of 1990.

The crop yields vary according to type of soil, which is why the spatial potential is subdivided according to soil type. Of all agricultural regions in the Netherlands, approximately 700,000 hectares can be counted as high-yield areas and 1.3 million hectares as low-yield areas. The ratio of productive and less productive land released for energy cultivation depends on the extent to which the claims are honoured. Nature claims concern mainly agricultural land of lower quality. At a spatial potential of 150,000 hectares in 2000 for the basic supply, the ratio between high-yield and low-yield land is 1:1.4, resulting in 63,000 hectares with a potential high yield and 87,000 hectares with a potential low yield.

### 2.2 Energy farming yields on agricultural land

Taking the estimated spatial potential and the division according to type of soil as a point of departure, it is possible to calculate the energetic potential. This estimate is based on Miscanthus as the energy crop, because it produces a high net energy yield. The yield figures were derived from data based on the model calculations (5). For the current situation 12.3 tons dm/ha/yr in high-yield regions and 10.6 in low-yield regions is projected. For 2015, 20% higher yields can be expected due to developments in cultivation technology, crop improvement and increasing experience with harvesting methods and maintenance. Using this data as a basis, a calculation was made of the annual yields in tons of dry solids. The net energy yield was calculated by combining the calorific value of the crops (19 GJ/ton dm) with the dry solid yield (gross energy potential) and deducting the energy costs of cultivation. For Miscanthus, this produces a net energy yield of 20 to 30 PJ per year for at a spatial potential of 100,000 to 150,000 hectares in the year 2000. At a potential of 245,000 to 375,000 hectares in 2015, a net energy yield of 62 to 95 PJ per year is possible. At a potential of 330,000 to 465,000 hectares, this would rise to between 83 and 117 PJ per year in 2015.

### 2.3 Energy yields as a secondary function

In addition to yields from energy crops on agricultural land, biomass yields can also be generated by non-agricultural activities and by-products of regular agriculture (waste flows such as organic waste and sludge have not been included). Yields from wood produced by thinning activities for forestry and recreation are particularly significant: approximately 15 PJ in 2000. Straw can contribute more than 8 PJ per year on the basis of the current agricultural hectarage. In the future, this contribution will fall as the hectarage for food production decreases. A yield of approximately 32 PJ per year is possible from secondary activities up to the year 2000. After 2000, this figure will fall to approximately 24 PJ per year by the year 2015 due to smaller straw yields on the one hand, and a lower proportion of thinning wood in the total volume of wood cut on the other. These figures assume that all claims for forestry have been honoured. If this is not the case, forestry hectarage will be smaller and the energy yield lower as a result. Table 2 shows a brief summary of the secondary yields. There is no data available for a number of biomass flows, and these have not been included in the table. In the case of these secondary yields, it should be pointed out that these flows already have an alternative application. For example, straw is sold to livestock farmers and the bulb cultivation industry, turf is composted and reeds are used for roofing.

Table 2 Overview of secondary yields of biomass

| Function | Type of material | Yield (ton ds/ ha/yr[1]) | Hectarage 1993/2000 (x 1,000) | Gross energy yield 1993/2000 (PJ/yr) | Hectarage 2015 (x 1,000) | Gross energy yield 2015 (PJ/yr) |
|---|---|---|---|---|---|---|
| 1 Forestry[1] | Thinning wood | 2.0 | 447/460 | 15.8 | 447[2]-497 | 11.2-13.1 |
| 2 Nature | Cut sods | 1.4 | 35 | 0.8 | 35 | 0.8 |
| | Reed | 4.0 | 11 | 0.1 | 11 | 0.1 |
| 3 Traffic | Verge grass | 5.1 | 37 | 2.6 | 37 | 2.6 |
| Parks and Gardens | Residual wood | - | +16 | 4.4 | +16 | 4.4 |
| Agriculture | Straw | 3.7 | 149 | 8.3 | 75[3] | 4.2 |
| Total | | | 695/708 | 32.0 | 621-671 | 23.3-25.2 |

1 Including forestry designated for recreation, nature and military training grounds.
2 Lower limit if none of the claims for forestry are met (and a consequent maximum spatial potential is achieved).
3 Assuming that the hectarage of grain falls by 50% due to the increase of spatial potential of energy farming.

Table 3 An overview of spatial potential and total energetic potential in 2000 and 2015.

| | | Basic supply | Higher supply |
|---|---|---|---|
| Spatial potential 2000 (x 1,000 ha) | Energy farming | 100-150 | 135-185 |
| | Secondary yields | 708 | |
| Energy yield 2000 (PJ/yr) | Energy farming | 20-30 | 27-37 |
| | Secondary yields | 32 | |
| Total energy yield 2000 (PJ/yr) | | 52-62 | 59-69 |
| Spatial potential 2015 (x 1,000 ha) | Energy farming | 245-375 | 330-465 |
| | Secondary yields | 670-620 | |
| Energy yield 2015 (PJ yr) | Energy farming[1] | 62-95 | 83-117 |
| | Secondary yields | 25-23 | |
| Total energy yield 2015 (PJ/yr) | | 87-118 | 108-140 |

1 This figure assumes higher yields of dry solids (20% increase) than in 2000. Taking the same yields of dry solids as in 2000, the figures would read 50-84 PJ/yr for the basic supply and 67-94 PJ/yr for the higher supply.

## 3. DISCUSSION AND CONCLUSION

The spatial potential of biomass is made up of two components: energy cultivation on agricultural land and potential biomass yields on land with another function. The net supply of land adds up to 100,000 - 185,000 in 2000 to 245,000 and a theoretical maximum of 465,000 ha in 2015. When this potential is used for energy crops like Miscanthus this land could contribute 20 - 37 PJ in 2000 and in 2015 62 - 117 PJ. Secondary yields of biomass can contribute a further 32 PJ in 2000, decreasing to approx. 24 PJ in 2015. In the year 2000, the total potential contribution of these two flows of biomass can contribute approximately 2% to the primary energy demand (as estimated in the Follow-up Paper on Energy Conservation (6)). In 2015, this total can be about 3%. The expected growth in energy consumption has already been calculated into these percentages.

A linear extrapolation is made up to 2015 for the potentially available land. It should be pointed out, however, that the WRR study entitled 'Ground for Choices' does support the theory that more land than estimated in the base calculations may become vacant. It may then become possible to achieve the results of the greater supply variant (410,000 hectares per year), which was conducted in the LEI study as a sensitivity analysis: a spatial potential in 2015 of between 330,000 and 465,000 hectares.

Compared to the study 'The feasibility of biomass production for the energy system in the Netherlands'(7), the estimate of energy potential on agricultural land is clearly lower. The study calculated a yield of 140 PJ. The fact that the estimates in this study lag behind has a variety of causes. Firstly, the calculation of the spatial potential in this study according to the basic supply is significantly lower (245,000-375,000 hectares in 2015) than the maximum estimated long-term spatial potential of 500,000 hectares in the mentioned study. Secondly, this study has assumed lower yield figures and differentiated according to land quality. Thirdly, this study has deducted the energy costs of the cultivation from the potential. It does, however, employ a higher calorific value based on data from recent research material.

## ACKNOWLEDGEMENTS

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