Income Options in Using Landscapes for the Production of Industrial and Energy Timber in Plantations – A report of practical experience

Dr. Jörg Köhn[1] & Arion Fichte[2]

Due to the changing conditions in agricultural policy of the European Union the opportunities to change production modes towards timber plantations to produce timber for industry and energy purposes on agricultural land become feasible. This is in line with support strategies against climate change. Public and private research is now focussing on the viability and economic feasibility of stock growth. The paper reports on private initiated and conducted research and practise. The results are promising and show that the grow of timber on agricultural land offers many options for wise soil and stock management that may be all in one economic profitable, ecologically sound and climate protecting. Moreover, using combined strategies of use may open good options for farmers who are willing to diversify their business as well as for the timber industry and energy business. The paper provides an overview about different species and varieties of plants to grow, landscape management schemes and the economics behind.

Introduction

There is an increasing interest in using renewable resources for industry and energy production. Enhancing the yields in especially timber plantations is therefore of industry but also farmers interest. The interest has many foundations that one might differentiate into socio-economic and political, for instance labour market, regional economics and income options, or ecological targets such as strategies against climate change, conservation of land developed and cultivated by man.

The paper exploits the frameworks to change the mindsets to make agricultural timber plantations economically competitive to other agrarian crops. The paper reports on experience that may assist strategies that are economically feasible as well as ecologically and socially sound.

Framework conditions

Political targets

The political context in the European Union to give support to set a stimulating economic framework. The European strategy includes

- EU guideline for the use of green energy
- National laws that assure quota or direct regulations of prices for the supply of renewable energy

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- EU trade with emission certificates, that make fossil fuel use because of carbon dioxide equivalents more expansive and green energy more competitive.

However, also the pressure of EU cutting the subventions for agriculture on a crop based framework towards a land benefit system may push the development.

Growing timber for energy uses might be an option for farmers to protect their income level and to use abounded land with marginal agricultural productivity. The EU recently extended the maximum rotation for agricultural long-term cultures from 10 to 20 years. The latter fact allows among others re-thinking the strategies for timber growth as an agrarian crop. In addition, emission trading excludes bio-energy by EU regulation in the first two trade periods.

Industry response

Since biomass is exempt from emission trading as an input to power stations industry tries to substitute fossil fuel to safe certificates, that is similar to cash money now. Industry increased development efforts into so-called Circulating Fluidised Bed Reactors in which it may co – combust bio-inputs. The rate of substitution may increase to 10 per cent of total inputs.

For this reason the timber market timber for energy production (combined power and heat stations) will increase substantially. However, this market requires ranges of timber that allows for European wide logistics. One assumes that this market will have the same requirements for transportation as the timber market for industrial uses has (logs, stems, wood chips, Helynen et al., 2005).

Farmers interest

Taking the point of view of farmers they will be willing to transform their land into timber plantations only if they may earn a comparable income from their fields as they do with crops like rape seed, wheat or rye.

Ecological targets

Trees are similar to solar plates but they grow and may store solar energy in timber. They take up carbon dioxide and transform it through photosynthesis. If one uses timber for energy purposes the carbon dioxide balance is more or less neutral over the time span of one rotation plus use period (if timber is used for furniture, construction etc.). However, the balance also is more or less neutral if timber is not used by man since the decomposition of timber by fungi and bacteria frees the almost the same amount of carbon dioxide that has been transformed into timber in one full circle of “tree” life. Using timber for energy use is nothing else than competing with fungi and bacteria for the same resource. The use of timber is almost climate neutral.[1]

In addition to other ecological effects, the transformation of farm land into tree plantations also enriches the humus in soils. The humus layer in a forest binds in climax conditions about 2,4 times more carbon dioxide than the trees in their timber. As long as the climax is not achieved the new plantations accumulate carbon dioxide in the soil.

Experimental design

Trees in a forest grow under conditions of light limitations. The “solar plate” works not at an economic optimum although for reasons of groundwater protection it may work in an ecological optimum (long-term constraint) since the leaf gaps close when solar radiation and heat increases to protect water resources in the soil.

Spruce in forests may yield up to 12 t (dry mass) per year and hectare in the Middle of Europe, respectively. The artificial limitation for light through dense plantations in forests assure that industrial demands on straight logs are met in the market.

However, if one change the parameters to maximise grow per year and use the stock for combined industrial and energy use one may think of optimising light climate to enhance annual gross production. This was a crucial point for our experimental design.

Second, one usually cuts the trees in plantations for energy timber every three or four years to assure a continuous return on investment after one short rotation. In our experimental setting we changed the rotation cycle to increase the yields and to deliver also timber ranges for industrial demand. We anticipated that the increasing yields will make plantations economically and technologically more feasible.

In addition, we expected that the microclimate within the stand may stimulate the grow of the individual trees.

Fourth, we also postulate that if we optimise light climate and improve the ecological “climate” in fields laying out an area of cultivation as edges in the fields we may also increase both the yields in timber production but also in the production of agricultural crops.

In addition, trade-off effects for the overall ecological system are expected (integrated pest management, reduction of soil erosion, habitats for songbirds and other animals).

We observed poplar, willow and alder plantations for more than 8 years.

[1] The fossilisation of timber to coal or oil in very long periods of time is an exception to this general rule. Coal and oil store carbon that initially was carbon dioxide in the atmosphere in pre-historic times. These times the carbon dioxide content of the atmosphere was significantly higher than today. Turning around this fact coal and oil conserve our climate today as long as they are not in use. Although, the demand world economy does not exceed the capacity of ecosystems to renew the resources bases man still has not the technologies and modes of production at hand that are economically competitive to the use of (politically/artificially) too cheap oil and coal.

Results and management recommendations

Selection of species and varieties

Yield maximisation requires to optimise between a set of economic, technical and ecological parameters that altogether will allow for the selection of management strategies and species or varieties to plant.

Soils

In general, one may grow timber on all agricultural soils. However, the use for timber plantations competes with the use for other agricultural crops. In general the transformation of farmland into tree plantation is not the first and most preferred option.

However, there are options for a combined cultivation of cereals and timber planted at the edges of fields. We learned from experience in South Europe that combined production of wheat and poplar shows surprising results. For instance, wheat crop on a 100 ha field equals a 100 per cent crop. If 30 per cent of the field were converted into a tree plantation at the edges at both sides of the field, wheat crop increases by 10 per cent on the remaining 70 ha acreages. That means that the crop was 110 per cent of only 70 per cent of area. The effects are due to the improved microclimate by the tree stands. However, the tree plantation must be large and old enough to achieve this effect on microclimate.

Nevertheless, this result may support our hypothesis that the overall "ecological climate" may improve the ecological conditions substantially. In addition, the timber crop is an additional surplus to the farmer who harvest almost the same amount of cereals and timber as an extra profit. If this result can be verified and falsified under other macroclimate conditions in Middle and Northern Europe or at other places too, this may support strategies for combined production of cereal and timber. Moreover, these results may support to change the common opinion that the grow of energy plants (at least timber) compete with food production and can not be an option as long as people starve and die for hunger. Quite the opposite may become a truth and may change the strategies of land use in many places of the world.

Unfortunately, we do not have evidence of such results for combined grow of cereals and timber (poplar) in our region. However, it seems to be of strategic importance to expand the experimental design to falsify this question also for Middle and Northern Europe.

As long as we do not have reliable results on the combined cultivation of grain and poplar (or other species) we pay attention to soils that are of low agricultural value (soils with marginal productivity).

We distinguish between sandy, clayish and organic soils. Soils for tree plantations should be close to groundwater table since maximising yields requires a water supply that on average exceeds the water consumption of trees in a forest. However, we

have to acknowledge a long-term drop of precipitation because of climate change since the Middle Ages.
Second, organic soils such as peat swamps might not be suitable for transformation into plantations since the initial effects of methane release from these soils are counter productive from the view of climate protection. However, the beds of lowland rivers are mainly formed by peat swamps and often covered by Alder and Willow stocks. A circulating harvest strategy like a mosaic for these existing stocks by cutting back to short stems in Alder or head cuts in Willow might be an option for economic uses of this timber. However, nature conservationist are very sensitive for the use of so called "Niederwald" structures.

Selection of species for the final use

Another parameter for the selection is the projected final use of the yields. Industry prefers logs and stems and wood chips (for OSB plates, respectively). Wood chips and stems are inputs to energy production too. The production of industrial and energy timber on agricultural fields may contribute to both use option when the trees can grow long enough. One rotation in poplar and alder should be longer than 6 years.
The share of industrial timber produced in these plantations will be about 40 per cent after 6 – 7, 60 after 8 – 9 and up to 80 per cent after 10 – 12 years. The other share is energy timber (wood chips and fine material for pellet production).

Selection for costs

There are three main factors influencing the cost structure of timber plantations.

1. costs for installation of a plantation and initial weeding
    - costs for purchasing or renting the land
    - costs for fencing
    - costs for seedlings or cuttings
    - costs for weed control
2. costs for harvest of the yields
3. costs for re-cultivation into agricultural land for ploughing.

In addition costs for administration and insurance are calculated. We estimate the same costs as in forestry management for a one per hectare calculation.
The initial costs highly depend on the overall strategy for the plantation. We calculate on long-term market observation average costs for purchasing the land 100 € per soil point, that is 3.000 € for a hectare of a 30 points soil or 50 € per hectare for renting the land.
Soil preparation, fencing and initial planting costs about 1.500 € on average. Weed control is about 350 € in the first two years. Administration and insurance add about 75 € per year. In total we calculate and credit about 5.000 € per hectare if land is in

possession of the owner of the plantation or about 2.500 € for rented land for one rotation cycle.
Harvesting costs are about 7 € per forestry m³ (Festmeter) for industrial timber (use in paper industry) and 20 € per ton for energy use.
We do assume that as long as timber plantations are declared as agricultural crops re-cultivation is not required. A second period of use for timber plantations will follow the first and so on. In case all re-cultivation into plough-land we have to calculate 2.500 €. These costs make the whole investment less attractive and will cause in short-rotation cultivations substantial losses (see below).

Selection of species and varieties

So-called pioneer species are most suitable to plant tree cultivations since other species grow slower or need a well established humus soil to perform good growth rates from the beginning or need shadow for initial development. In contrast, all pioneer species love sun, grow quick after a very short initial period and do not need soils rich in humus.
Therefore three types or species groups are well suited for tree plantations in Europe

- poplar (cuttings, head cuttings, various clones)

Table 1. Parameters for the selection of species for tree plantations.

Parameter	**Poplar**	**Alder**	**Willow (tree form)**
Soil	< 30 soil points, sandy, close to groundwater table	< 30 soil points, clay or organic, wet	< 30 soil points, clay or organic, wet
Annual growth	About 20 t/a dry mass	> 15 t/a dry mass	> 15 t/a dry mass
Use	Industry, energy	Industry, energy	Energy
Rotation	6 – 12 years	6 – 8 years, then cut back to 40 to 60 cm	> 5 years, then head cutting
Parallel uses	From the 2nd year	From the 3rd year	Head cutting from the 1st year, others from 3rd year
Damage by game	High	Low	Medium, head cuttings low
Fencing	Required	Required	Recommended
Initial plants	Cuttings	Seedlings	Cuttings, head cuttings
Initial costs	Because of fencing high	Because of seedlings high	Low to medium
Weeding	First two years	First two years	First two years, non with head cuttings
Harvest	Mainly by hand	Mainly by hand	Mainly by hand
Number of rotations	> 3	> 3 (?)	No limitations (?)

- willow trees (not brushes!; cuttings, stem cuttings, and head cuttings, e.g. Silver Willow)
- alder (seedlings, e.g. Black Alder).

Except of alder the other species can be planted as short cuttings (poplar and willow) or stem cuttings (willow, tree from). One may cut alder and willow for the first time after 6 to 8 years of growth. After first harvest willow may continue to grow as a head cutting tree or as Niederwald (alder) with usually 4 to 8 stems on as single root.
Table 1 summarises parameters that support decisions for species selection.

Growth and yield options

We tested various clones of poplar on weak sandy soils. The total area of plantation was about six hectares. The distance between cutting-to-cutting was initially about 1,5 m; we choose the same distance between rows. We planted about 8,600 cuttings per hectare. Depending on groundwater table we adapt the length of cuttings for planting. We cut the trees back to the soil surface to strengthen the root for stronger grow of the shoot after the first year. The roots are one year older than the shoots in our plantations.
We measured an annual growth rate of 2 cm in diameter and 2 m in height on average. This corresponds with measured a > 20 t dry mass growth a year without root mass. A six year stem may have a > 20 cm diameter already (measured for more than 35 per cent of all trees in the plantation). One may therefore harvest industrial timber for paper industry already in the seventh year after planting.
We harvested every second row in the seventh year, and every second tree in a row in the ninth year. The distance from tree to tree for the final growth is therefore 3 m. Final harvest is recommend for the 12th year.
Since the EU commission have extended the maximum grow period for long-term cultivations on agricultural land a longer rotation period may be feasible. The tree-to-tree distance after the second harvest in the 9th year allows for 20 year stocks.
One benefit of growing timber is that one may store and grow the resource on stock and harvest it on demand. This is not possible for other types of biomass cultivations.
We have to acknowledge, that harvest provides stress to remaining trees within the plantation. Compression of soil may cause one year of growth losses and is to avoid.
The growth rates in Alder and Willow are 1,5 cm in stem diameter and 1,5 m in height a year and the measured yields are about 15 t dry mass a year.
One may use the plantation if fenced as pasture for gooses from the third year. We prepare tests with other animals at present.
We recommend edge of field structures at least 50 m wide to stimulate a microclimate within the plantation, to assist short term decomposition of leaves (within 1 year) and to allow harvest throughout the year.
The longer rotation increases the ratio of timber and bark from year to year. Two effects go along with this ratio: lower export of nutrients (mainly located in the bark), less pollution with mineral waste (lower costs for industrial processing).

Since we changed the management scheme slightly we could deliver industrial and energy timber from the same area to different markets that makes the production less depending on actual prices in the one or the other market.

Sets for the management practice

To convince farmers to start with tree plantations it is important to

- assure no or low income losses in comparison to usual field crops such as cereal. Earnings should be equal to wheat profits (about 500 to 600 €/a*ha).
- use existing machinery as much as possible to avoid further costs.
- provide service and market access to the markets for industrial and energy timber.
- support long-term financing since earnings need a 6 to 8 year pre-financing (for instance, a timber stock market with funding by investment funds).

To make industry a partner for tree plantations requires to

- assure sufficient large supply figures, initially more than 1.000 ha planted to grow 20.000 t of timber a year.
- adapt to logistic products and logistic chains established in this market (logs, stems, wood chips).

Business model

Poplar plantations may produce in long-term rotations about 650 forestry m³ of timber. This figure is more than 4 times as much as in short-term rotations. In addition, short-term rotation hardly deliver timber for industrial use, consequently the benefits are substantially lower than in plantations with long-term rotation (fig. 1).

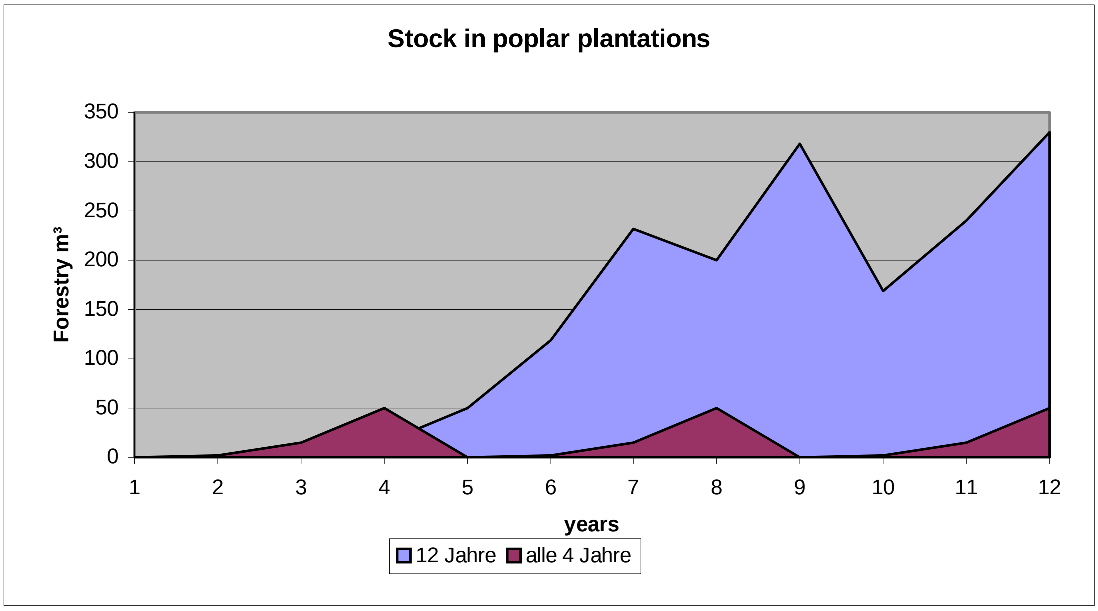

Figure 1. Stock (storage pool) in poplar plantations in a 12 (blue graph, harvest in 7th,9th and 12th year) and 4 year rotation (purple graph).

We already presented the structure of costs. The structure of revenues bases on market expectations that are in line with product quality, long-term monitoring of market prices and expectations related to the first period of emission trading. The latter has already affected timber prices.

We calculated 50 € per t dry mass for energy timber used in gasification stations (combined heat and power production), and 70 € per t dry mass for industrial timber (paper industry, 1 t dry mass = 2,4 forestry m³).

When comparing a short-term rotation (4 years) with a 12 year rotation in poplars we get the picture presented in figure 2. In a short-term rotation the gross proceeds are hardly positive (purple graph), whereas gross proceeds for long-term rotation periods earn profits with every harvest period (blue and yellow graph). Yellow and purple graph assume a 50 € rent for land a year; blue graph shows the results for purchased land.

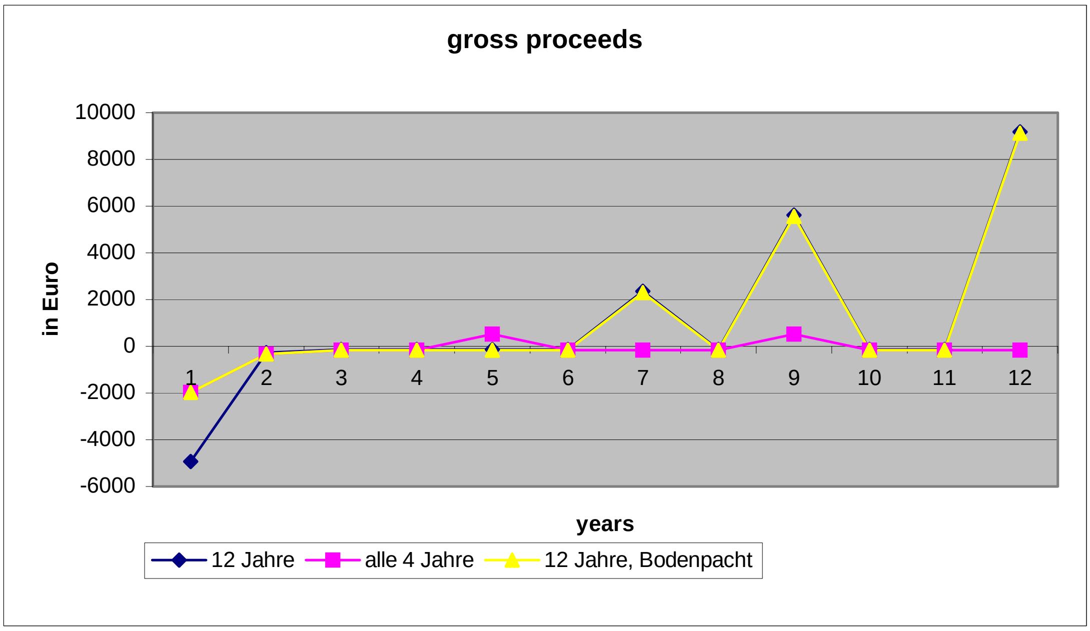

Figure 2. Gross proceeds of poplar plantations with purchased land and 12 year rotation (blue graph), rented land and 4 year rotation (purple graph), rented land and 12 year rotation (yellow graph). Interest is calculated with 4 per cent per annum.

When comparing data from a full cost analyses the picture is even worse. The plantations with short-term rotations will not cover the costs whereas poplar plantations with long-term rotation may earn a net profit of about 700 € per year on average over the whole rotation period (calculated with 4 per cent interest, prices for timber as mentioned above). In case of purchasing the land the second cycle without rent will allow for even better results (add 250 € a year and hectare, fig. 3).

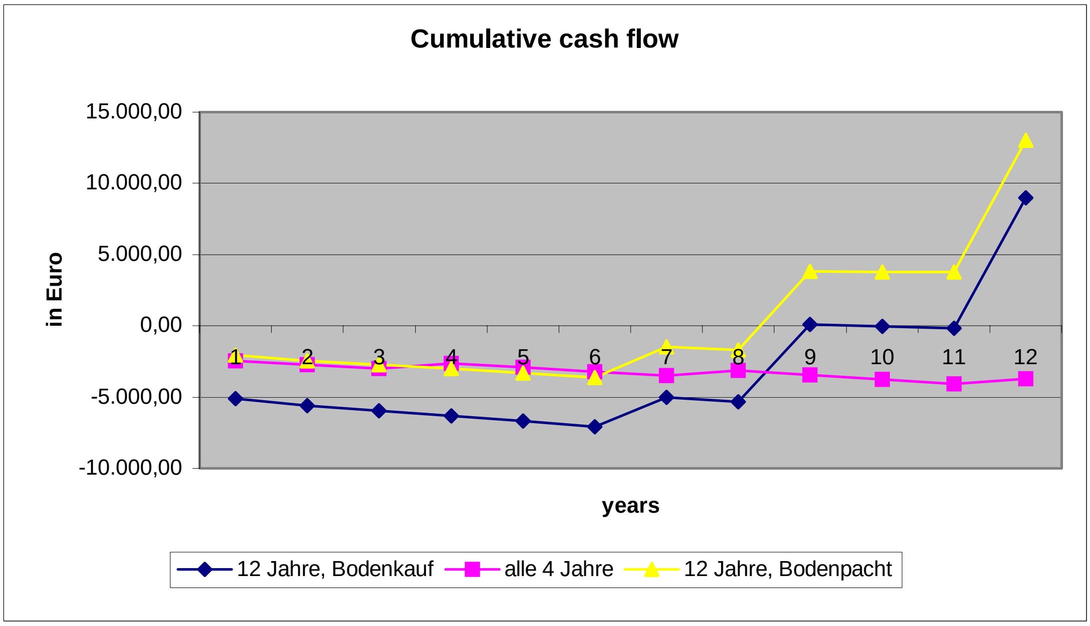

Figure 3. Cumulative cash flow for poplar plantations with purchased land and 12 year rotation (blue graph), rented land and 4 year rotation (purple graph), rented land and 12 year rotation (yellow graph). Interest is calculated with 4 per cent per annum.

The economic analysis shows that long-term rotations are the option to choose. There are economic but also ecological reasons (see above) to do so.

The data for alder and willow (trees) of lower economic interest because the net profits are about 25 per cent lower in alder and about 40 per cent lower in willow (energy use only). However, if costs for plantation can be reduced because of using existing stocks in lowland river beds and flats the picture will change. Moreover, a step-by-step extension of these stocks on organic soils might be an option of economic interest too. This is the more of interest since every subsequent rotation will compensate for initially lower yields.

Summary

Timber plantations even on soils with weak agricultural value are an economic, ecological and social opportunity for landscape and crop management. However, the rules of management should assure that the cultivations will still count into agricultural modes of production since forestry law may restrict uses and subsequent returns. A transformation of naturally grown lowland alder and willow stocks into cultivations might be an option of interest from the climate change point of view in the describe manner.

Although we are lacking experience for combined production of timber and cereals in the "same" field in Middle and Northern Europe but acknowledging good results from Southern Europe also agricultural soils with better qualities may offer interesting ecological and economic opportunities for a wise use of land.

However, to make really progress in timber plantation strategies some of the today paradigms have to be changed. Plantations with long-term rotations are much more ecologically important to the landscape development and climate protection since they create a self-sufficient microclimate, may protect water resources and form sustaining fertiliser (humus) cycles. Second, the long-term rotations are the only one that are also economically feasible when calculating full costs. Third, these cultivations may make the difference since they deliver goods for industrial and energy use.

Literature

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[1] Beckmann Institute for biobased products (BIOP) e.V., Regional Office North, Büdnerreihe 20A, 18239 Heiligenhagen

[2] Arion Fichte, dt Maschinen- und Anlagenbau, Annenhof, 17379 Lübs