

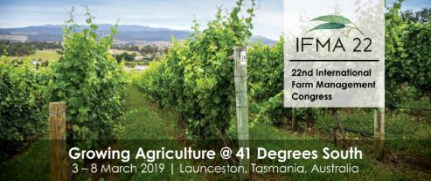
An aerial photograph showing two white wind turbines in a rural landscape. The turbines are situated in a field with a mix of brown and green patches. A line of green trees runs diagonally across the middle of the image. In the lower center, a blue tractor is visible in a field. The overall scene depicts the integration of renewable energy infrastructure into agricultural land.

# WIND TURBINES IN GERMAN AGRICULTURE – NO RISK, NO GAIN?

CURRENT SITUATION AND ECONOMIC VIABILITY

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# Outline

1. Introduction
2. Regulations for the approval of wind turbines
3. Methodology
4. Break-even calculation for a wind turbine
5. Stochastic simulation of wind yields
6. Considering risks of approval
7. Interviews with farmers
8. Summary/Conclusions



## 1. Introduction (1)

Worldwide agreement:  
avoiding dangerous climate change  
by reducing emissions of Green House Gasses  
(IPCC; EC-Commission 2007; EWEA, 2011).

Germany in the year 2000:  
Law for the Development of Renewable Energies  
„Gesetz für den Ausbau erneuerbarer Energien,  
Erneuerbare-Energien-Gesetz (EEG)

"The aim of this law is to increase the share of electricity generated from renewable energies in gross electricity consumption to ... 40 to 45 % by 2025" (EEG 2017, § 1 (2))

Goal: 80% share of renewable electricity by the year 2050



## 1. Introduction (2)

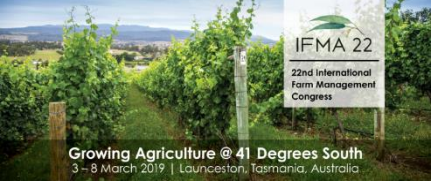
Gross electrical power generation in Germany increased from 576.6 TWh to 651.8 TWh (2000 to 2015).

The share of renewable energy sources (from hydro power, wind, solar, biogas and other biomass) has risen from 6.5% to 32.6%.

Wind power accounted for 9.5 TWh in 2000 (on-shore only), which was increased to 79.3 TWh on-shore and 8.7 TWh off-shore in 2015.

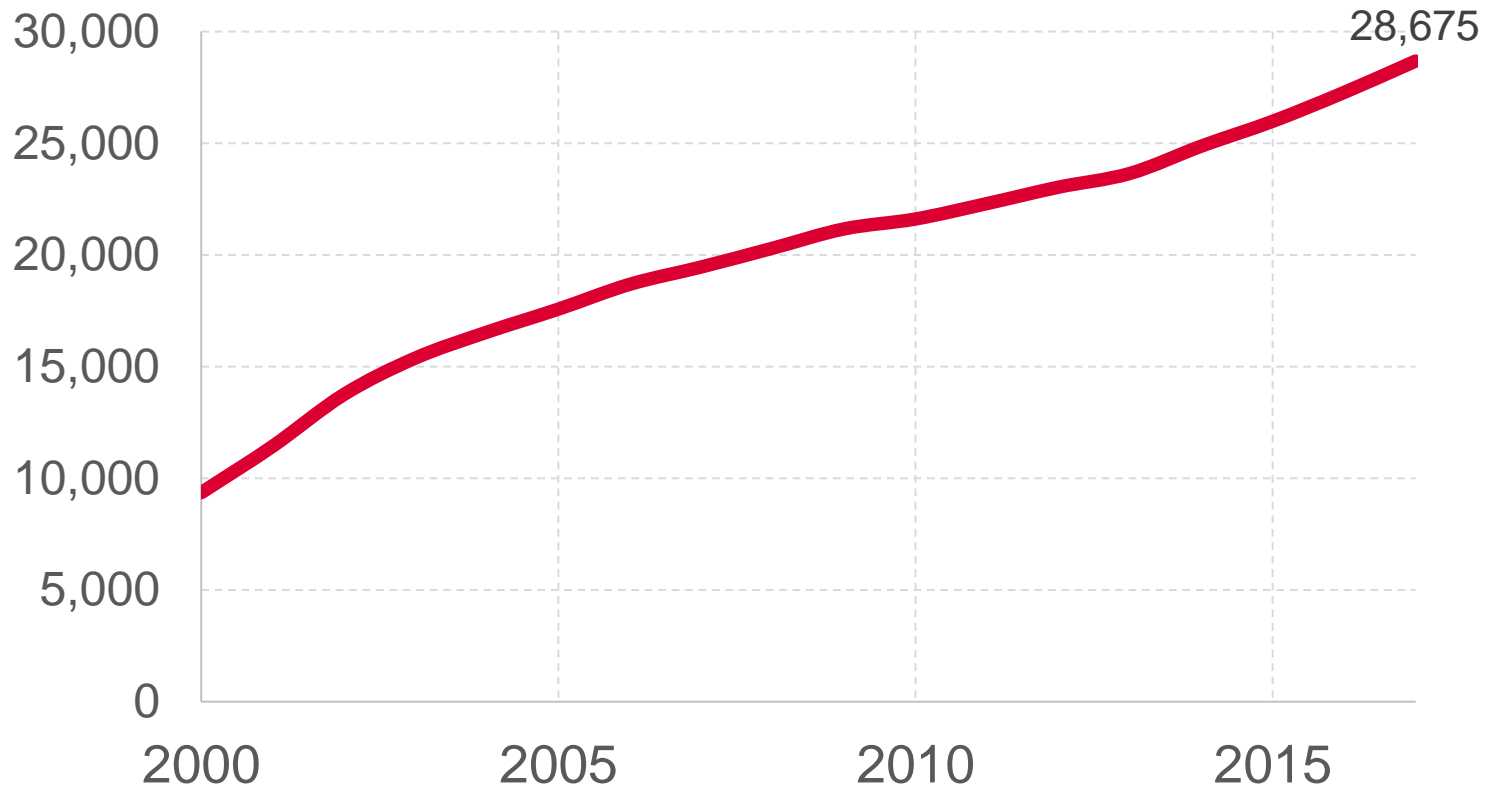
The wind turbines thus produce the largest share of renewable energies, followed by biomass with 44.2 TWh and photovoltaic 38.4 TWh, each in 2015 (BDEW Energy Info 2016).





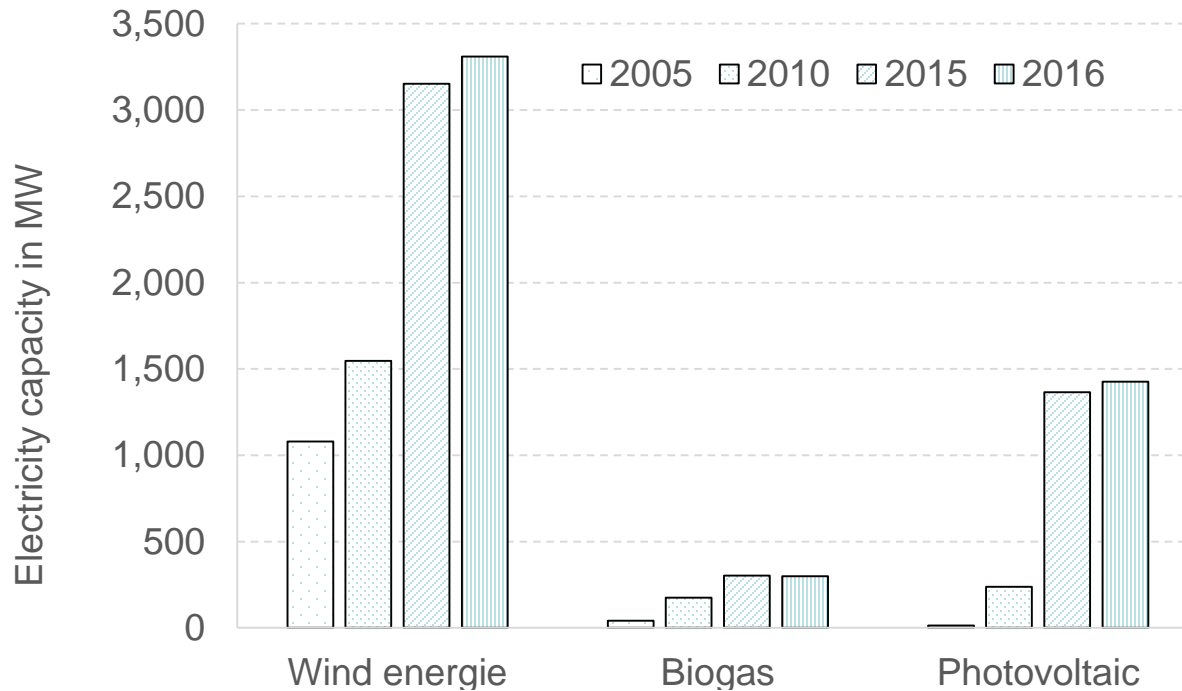
# 1. Introduction (3)

Development of the number of on-shore wind turbines in Germany (2000 to 2017)

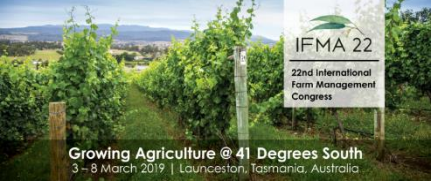


# 1. Introduction (4)

Development of electricity generation from renewable energies in the Federal state Mecklenburg-Western Pomerania



**New designated areas for wind energy below 1% of the land area of Mecklenburg-Western Pomerania; => potential for further investments**



## 1. Introduction (5)

### Wind energy means

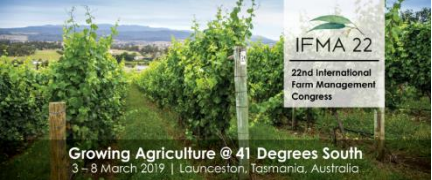
- income opportunities for the agricultural firms and also additional tax revenue for the municipalities
- owners of land, they have the opportunity for investments in their own wind turbines or to lease the location of wind turbines to investors outside of the agricultural sector.
- However, the necessary investments for a modern wind turbine with the capacity of about 3 MW sums up to millions of Euro. Even at the planning stage, considerable costs are incurred for appraisals and approvals amounting to approx. 7% of the total investment that would be lost in the case of non-approval.
- Therefore, our hypothesis was, that farmers must be prepared to take special risks e.g. related to uncertain results of permit procedure.
- The regulations for constructing a wind turbine are an integral part of planning a wind farm or a single wind turbine, which tie up a lot of capital in advance.



## 2. Regulations for the approval of wind turbines

- **Federal legislation**
  - Federal Construction Act (BauGB)
  - Air Traffic Act (LuftVG)
  - Road using right
  - Federal Nature Conservation Act (BNatSchG)
  - Federal Emissions Control Act (BImSchG)
  - Environmental Impact Assessment Act (UVPG)
- **Regulation of the federal states**
  - Country construction order
  - Height limit and distance regulations
  - Spatial planning and
  - Regional planning
- **Responsibility of the municipality**
  - Designation of priority areas
  - Creation of land use plans
  - Examination of admissibility
  - Granting of the building permit





### 3. Methodology

- Deterministic calculation of total costs and **break-even analysis** for a typical wind turbine currently constructed in North-Eastern Germany.
- **Farmer interviews** to learn more about motivation, the benefits and the obstacles of own investments in wind turbines.
- **Stochastic simulation considering** the risk of fluctuating wind yields (triangle distribution of production of electrical power: median 3,200 +/- 500 full load hours).
- **Net present value comparison** of own investment versus revenues from leasing a wind turbine site taking in account risk tolerance according to the Hurwicz criterion.

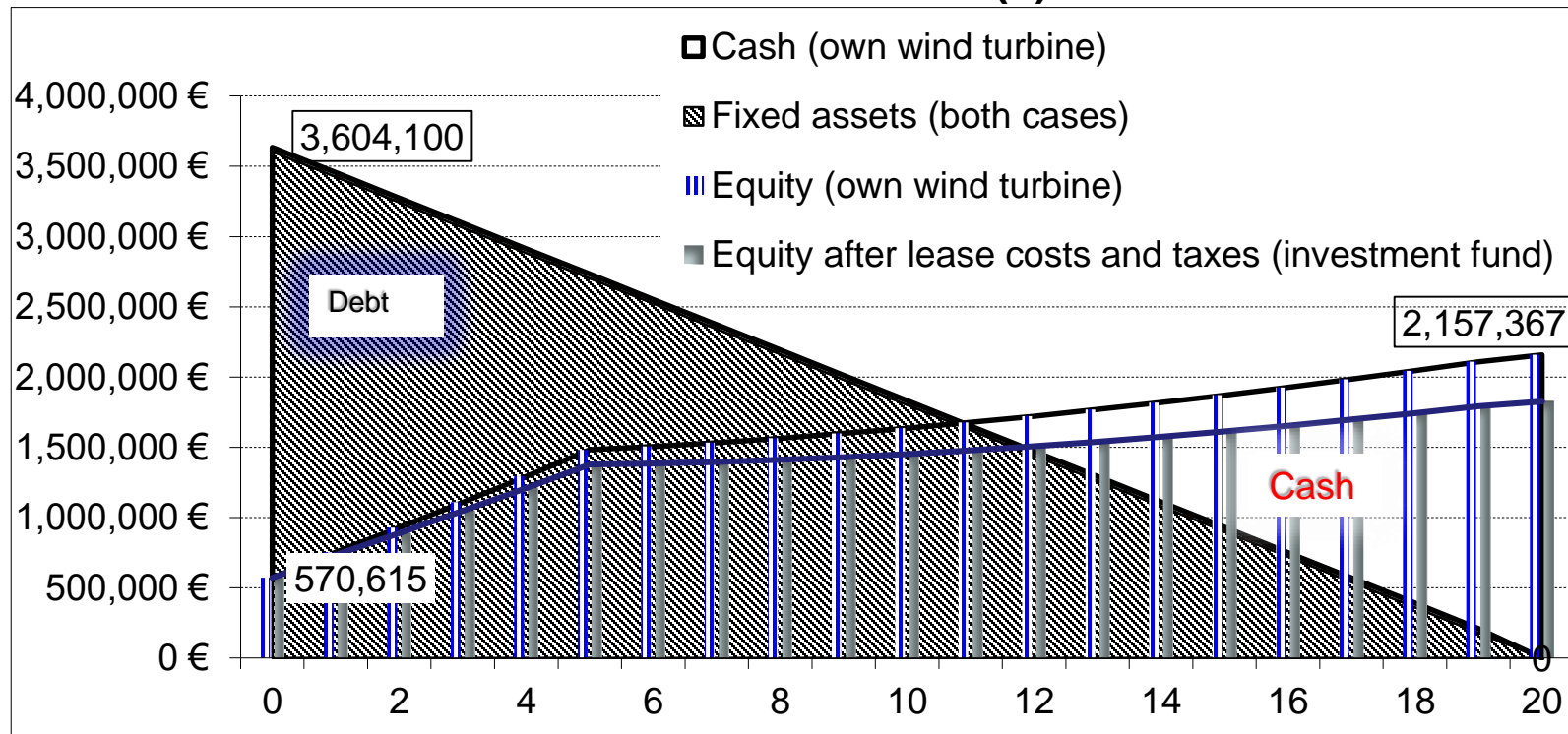


## 4. Break-even calculation for a wind turbine (1)

Assumptions for the break-even calculation of a wind turbine

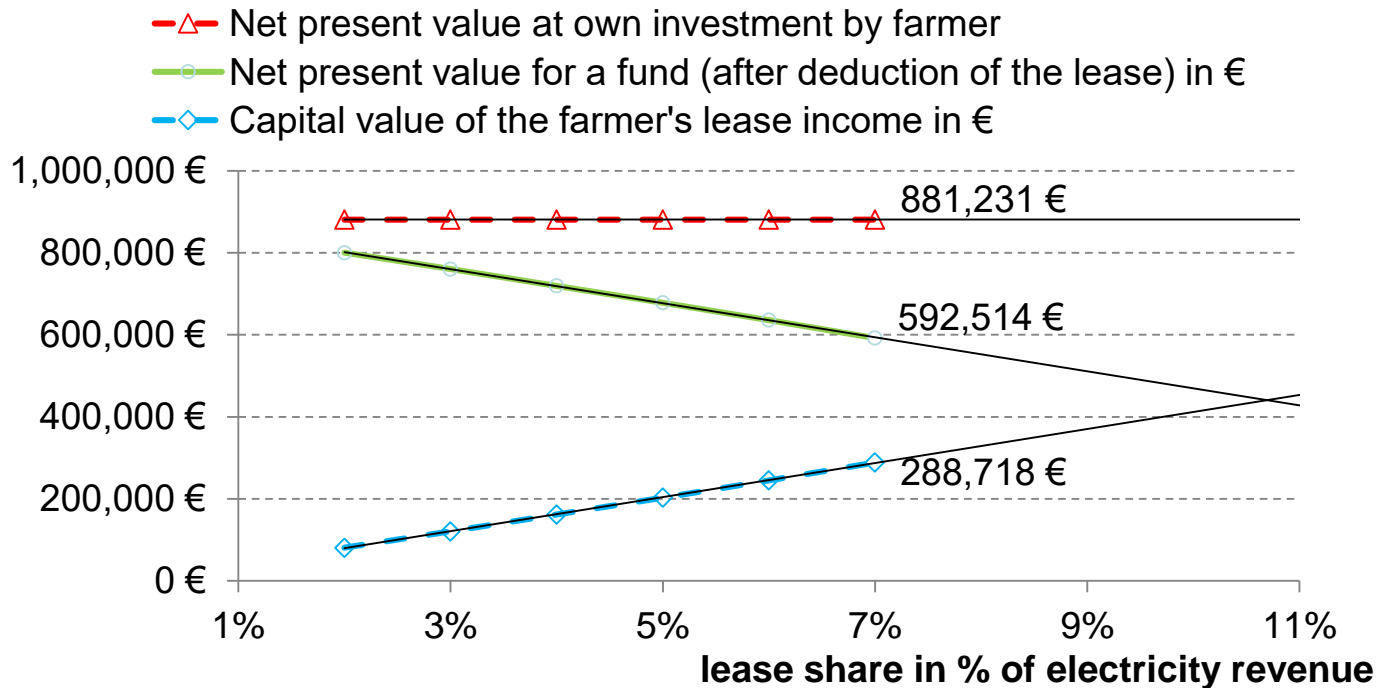
Key figures	Unit	Amount
Size of the wind turbine	MW	2.300
total investment	€	3,604,100
from that: planning and approval costs	percentage / amount in €	7% / 252,287
Own funds of investor/farmer	€	570,615
Interest of loan	% p.a.	2.5
amortization period	Years	20
Feed-in-tariffs:		
- first five years	€/kWh	0.0890
- following years	€/kWh	0.0495
Capacity utilization	full-load hours per year	3,200

## 4. Break-even calculation for a wind turbine (2)



Amount of investment in  $t_0$  (3,604,100 €), necessary equity capital in  $t_0$  (570,615 €), development of fixed assets and cash surplus for a wind turbine depending on the investor (farmer or external investor); here: lease share 5.5% of the electricity revenue

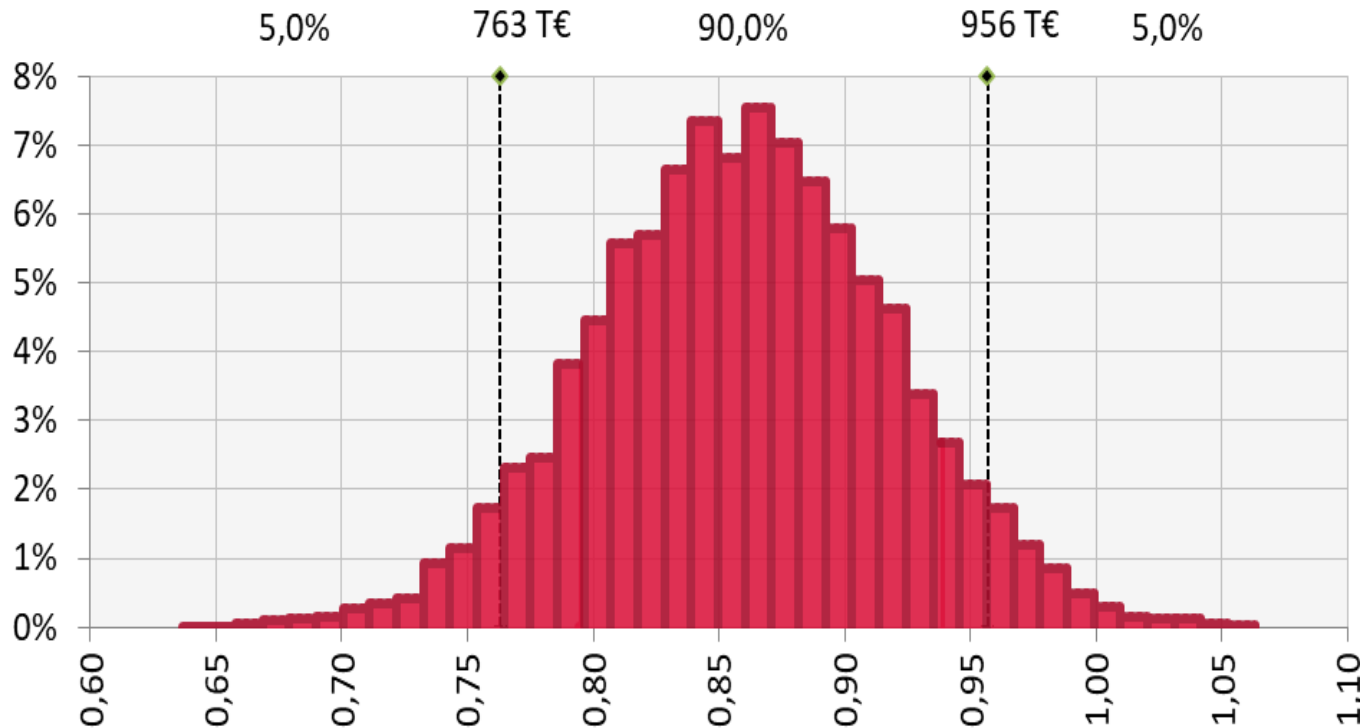
## 4. Break-even calculation for a wind turbine (3)



Net present values of the investment of a wind turbine in the case of own investment by a farmer or by an investment fund together with the net present value of the lease payments; latter depending on the lease share of the electrical revenues; all values after taxes

## 5. Stochastic simulation of wind yields

### Wind turbines pay off even with fluctuating wind yields!



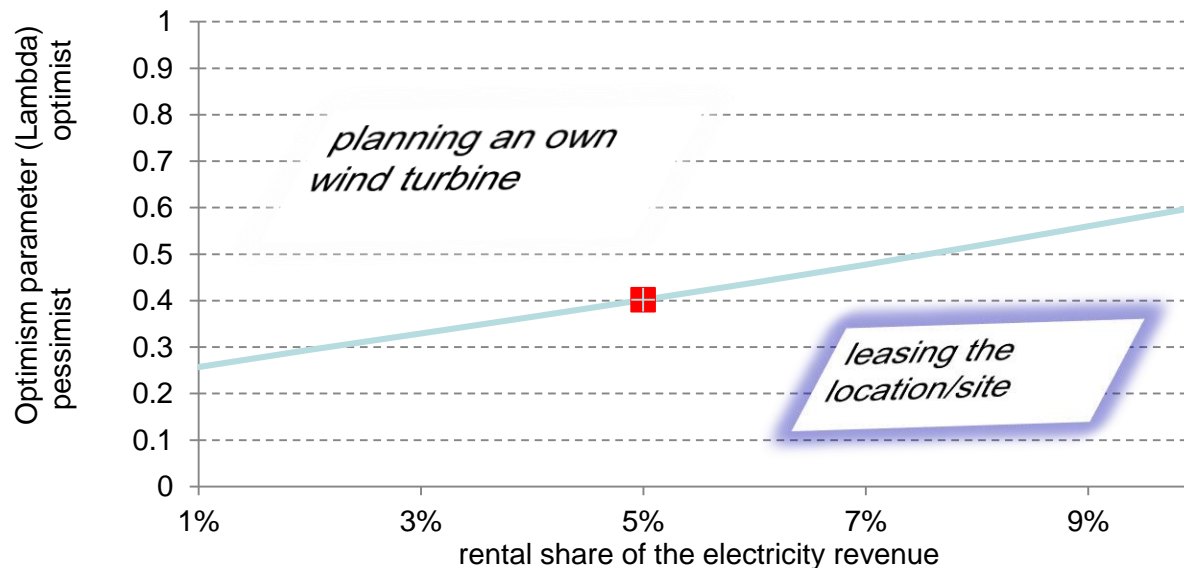
Distribution of net present value in million Euro of one wind turbine with fluctuating full load hours (3,200 h +/- 500 h as a triangular distribution, 10,000 simulations with @RISK)



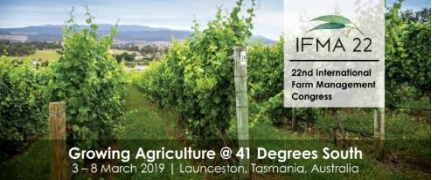
## 6. Considering risks of approval

Net present value of lease income =	loss of planning costs <small>worst-possible result</small> * (1 - λ) + Net present value's own wind turbine <small>best possible result</small> * λ	(1)
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Net present value of lease income 202,870 € =	loss of planning costs of € -252,287 * (1 - 0,4) + Net present value of an own wind turbine in the amount of € 881,231 * 0.4	(2)
(5% rent share of the electricity revenue)		



Decision to start planning a wind turbine with an uncertain outcome compared to leasing the site depending on the rental share of the electricity revenue and the investor's risk attitude



## 7. Interviews with farmers

Two farmers have themselves set up wind turbines and additionally leased locations to other investors. The third farmer has leased all sites to an investor in the region.

Wind turbines were built in 2000/2001, 2013/14, 2014/15 and 2016; sizes between 2.3 and 3.45 MW.

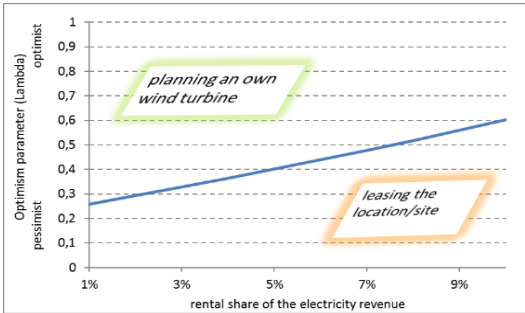
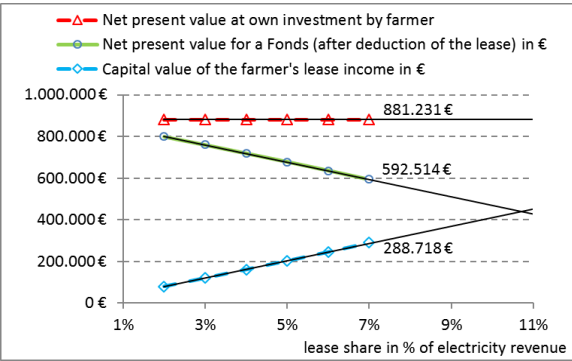
### Reasons for lease

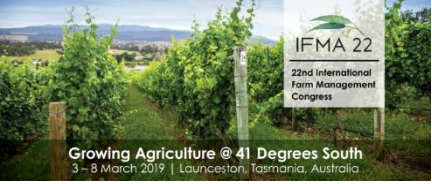
- necessary high capital need (10% of the total investment volume)
- scarce capital due to purchase of farming land
- strategy: in a first step by land and built wind turbines at a later date (also a form of risk splitting).

None of the farmers directly involved municipalities or citizens but provided funds to the communities, e.g. to support fire-fighting



## 8. Summary/Conclusions (1) Decision support schemata

Availability of equity capital	State of the approval	
	Site unsure – not yet approved	Exists, e.g. expansion of an existing wind park
Own equity missing	waiting; keep option for leasing	Search for investor / leasing the location
Own equity available	<p>Test risk attitudes, then decide</p>  <p>Decision to start planning a wind turbine with an uncertain outcome compared to leasing the site depending on the rental share of the electricity revenue and the investor's risk attitude</p>	<p>Own investment; profits higher than leasing earnings</p>  <p>Capital values of the investment of a wind turbine in the case of own investment by a farmer or by an investment fund together with the net present value of the lease payments; latter depending on the lease share of the electrical revenues; all values after taxes</p>



## 8. Summary/Conclusions (2)

Wind turbines can be very profitable; to build a wind turbine

- a building permit must be requested and granted
- a high equity ratio of 10% to 15% is needed
- farmers priorities for land purchase have to be respected.

Higher leasing earning and risk attitudes tend to prefer leasing of an appropriate location.

Division of several sites into leasing and own investment can also be considered as minimizing risk.

The lead of the funds is definitely.





Vielen Dank für die  
Aufmerksamkeit!

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