

Denmark – the Wind Power Pioneer

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**Wind Energy in Western and Eastern European Countries –
the interaction of driving forces in the process of innovation
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- Phases of Danish Wind Power Development
- Historical Danish Wind Energy Policy
- Modern Phases of Danish Wind Power
- Main Features of Danish Wind Energy Policy
- Strategic Elements of Danish Wind Policy
- Installed Capacity and Yearly Growth of Wind Energy in Denmark
- Explaining Factors
- Conclusions

1. Historical Phase (1890s-1967)
2. Upraise of modern wind power & step-by-step efficiency enhancement (1973-1989)
3. State intervention pro wind power (1990-2001)
4. Stagnation on-shore and expansion of off-shore wind power (since 2002)

- Long historical development: Poul la Cour in the 1890s.
- Rotor diameter of 22 m with mechanical speed control.
- Testing of rotor profiles in wind tunnel.
- Producing hydrogen by electrolysis of water (for illumination).
- In 1918, 120 rural wind power stations in Denmark with a total capacity of 3 MW, covering 3% of Danish electricity demand.
- 200 kW Gedser wind mill in operation 1957 to 1967: three blades on a horizontal axis in upwind position. Supported by the utility SEAS.



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- Starting in the mid 1970s with the Gedser Mill as the "mother concept" promoted by small private entrepreneurs. Turbine capacities beginning at 22 kW.
- Support from the Danish Academy of Technical Sciences and Danish NGO's.
- Ridiculed by utilities and supporters of nuclear power.
- Heated debate on nuclear power from 1974 to 1985.
- Official energy plans (1976, 1981) with nuclear power, alternative plans without nuclear (1976, 1983)
- Supporters of RES and opponents of nuclear power were accused of trying to overthrow Danish democracy.

Main Features of Wind Energy Policy

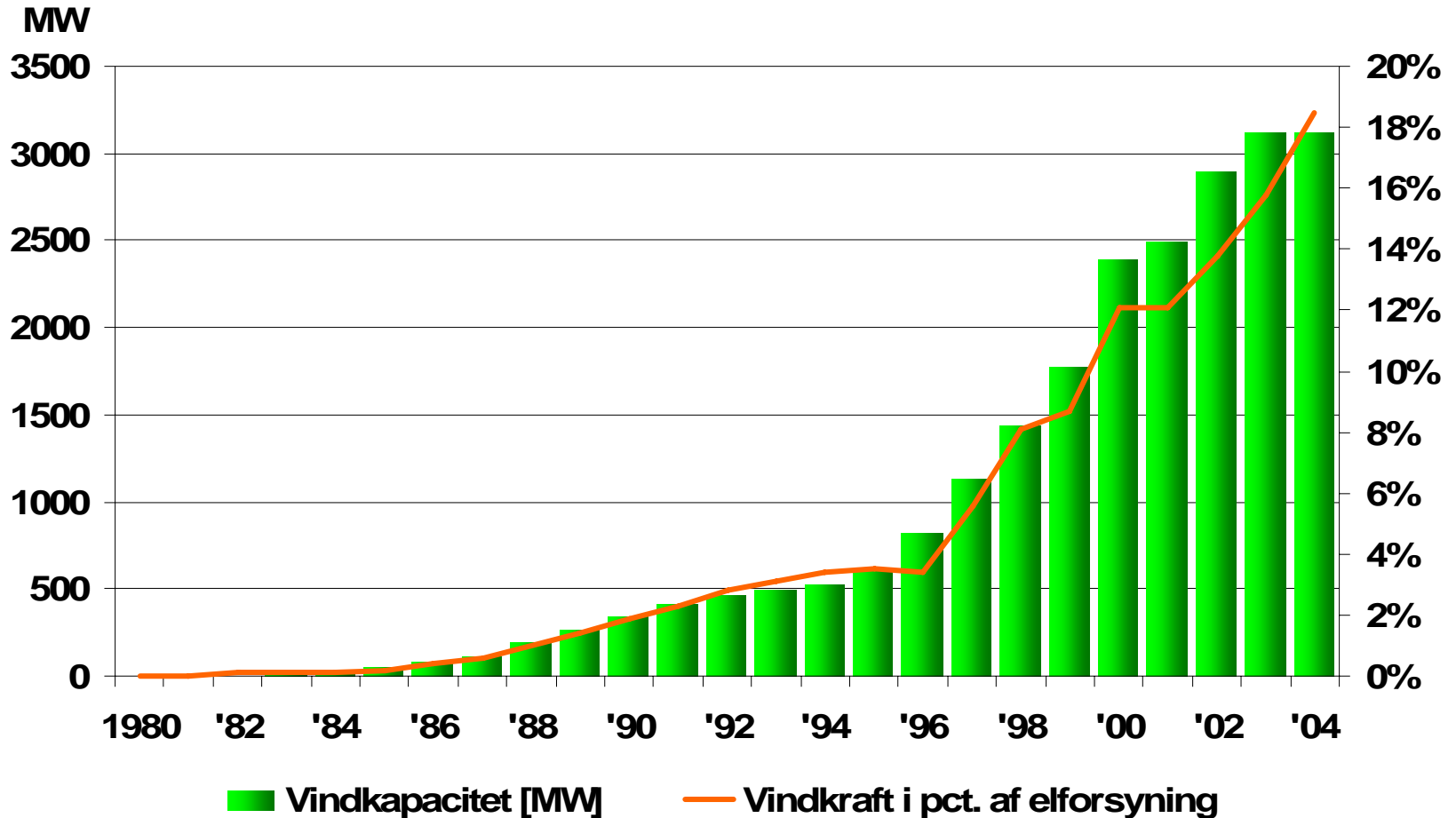
- 1976 to 1990: modest room for wind in official plans, voluntary agreements between utilities and wind energy producers, some state support for research/development
- 1990: state intervention against municipal and regional barriers
- 1990: New energy plan with main goal: sustainable energy development. Follow-up in 1996.
- 1992: State rules for wind tariffs and grid access.
- 1994 to 2002: Rapid growth in installed wind capacity.
- 2003-2006: Stagnation in new wind capacity after change of Danish government in 2001.

- Long-term government support for R&D.
- Early national tests and certification of wind turbines.
- Safe technological development from small to large size.
- Siting rules caring for the environment and dwellings.
- Local ownership of wind turbines, mainly co-operatives – 150,000 households involved in 2002.
- Favourable feed-in tariffs from 1992 to 2002: 8 €ct/kWh.
- Specified and ambitious targets for RES-E in official energy plans from 1990 and 1996: 1,500 MW wind in 2005 and 5,500 MW in 2030 (4,000 MW offshore).

Danish Wind Power Innovations

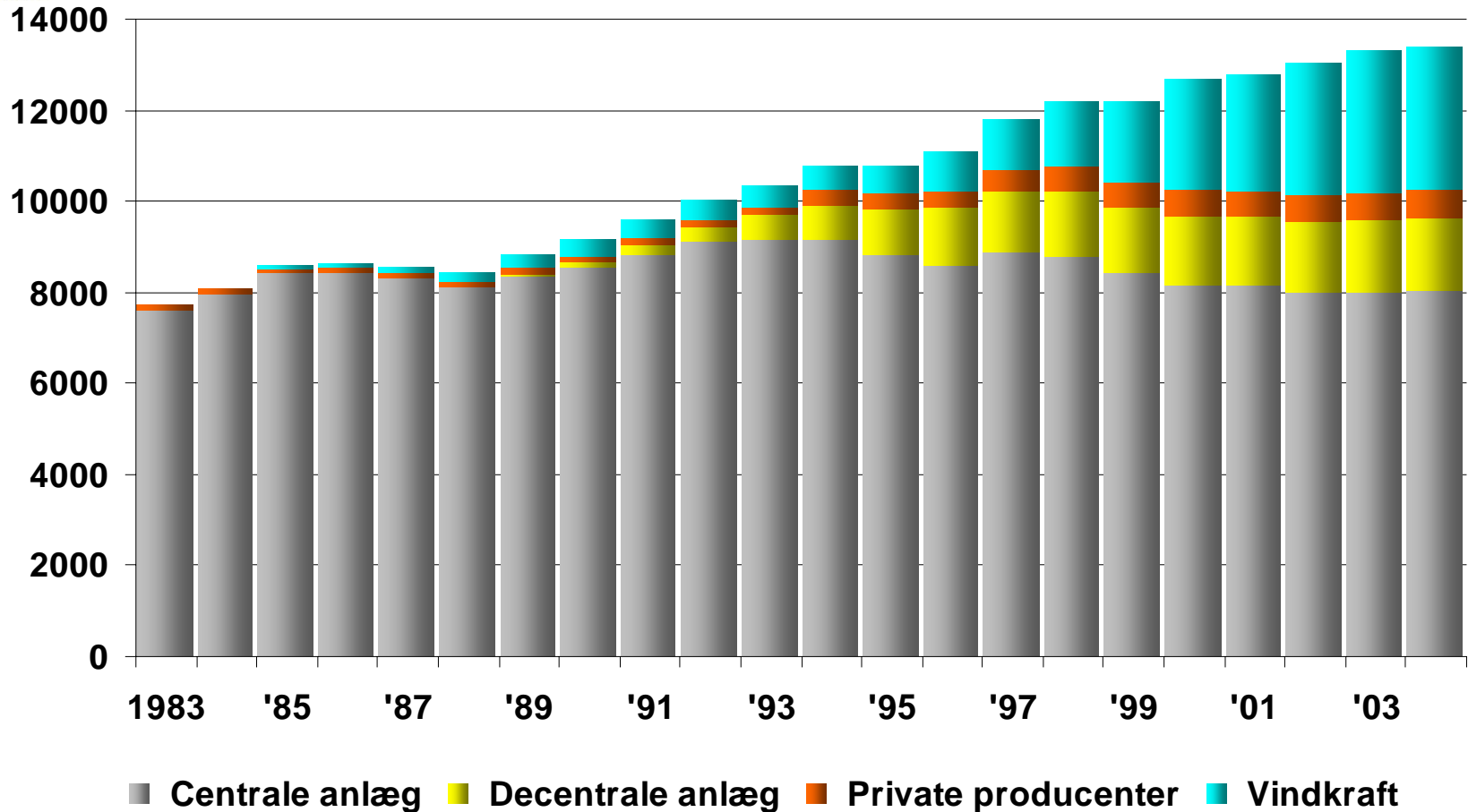
- Three blades
- Running direction
- Wings development
- Gearing (two gears)
- Blade pitch
- Wind atlas
- Energy plans / alternative energy plans
- Feed-in tariffs

Installed Wind Power Capacity & share of electricity generation



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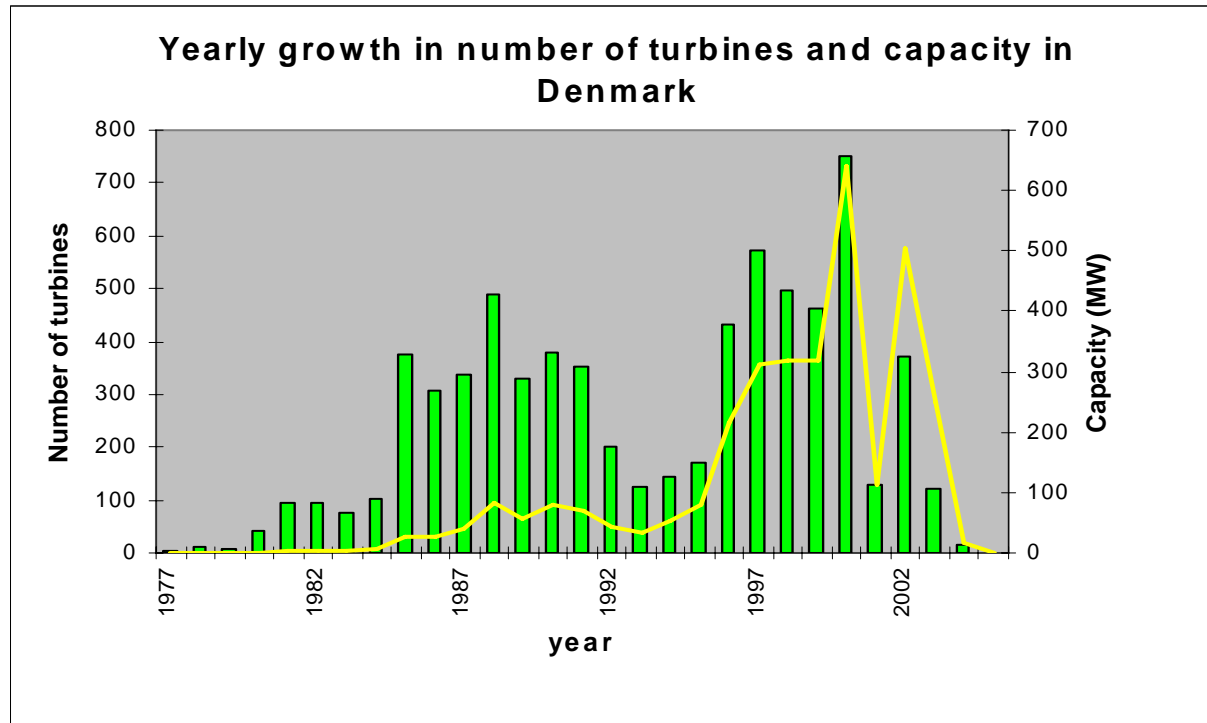
Installed Power Station Capacity



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Yearly Growth of Wind Turbine Capacity in Denmark

Green columns indicate number of turbines, while yellow curve indicates yearly installed capacity (MW). Net increase in capacity close to zero from 2004 to mid 2006.



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- Driving forces
- Regulative impulses
- Technological development

- “Green” majority in Parliament in the 1980s.
- Alliances between NGOs and academic institutions.
- Local ownership of turbines (150,000 co-operatives).
- Agreement between government and utilities to operate wind turbines.
- Private industrial entrepreneurs leading to large production plants in the 1990s.
- Far-sighted government plans from 1990 and 1996 including ambitious capacity targets.

- Feed-in tariff (1992-1997)
- EU Commission drafts of harmonisation of RES-E support systems
- Anticipatory obedience by Danish Energy Authority and the Danish Government (1997)
- Trading of green certificates – ending up in chaotic transition rules
- conservative-liberalistic government with fundamentalist market policy (since 2002)

- Historical tradition and step by step increase in capacity.
- Early test and certification institution at Risø and early state support for R&D including offshore farms.
- Vestas and special blade company as innovator of rotor blades

- Governmental energy policy is a decisive factor for penetration of wind power.
- Favourable feed-in schemes have so far proved to promote wind power most efficiently.
- A sustainable energy development requires fluctuating RES as a significant element in the supply system, e.g. 50% before 2030.
- High fractions of fluctuating RES-E require these plants to actively support the overall system balance.
- Development of such systems should have high priority.

Thank you for your attention!

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