The Turby concept

The necessity for renewable energy

- Large wind turbines - *public issues*
- Photovoltaïcs - *not economical*
- Small wind turbines - *attractive, but need height*
- Height essential - *but expensive*

Use available height BUILDINGS

Urban Turbines

Design criteria

Safety

Good price / performance ratio

- Good efficiency
- Low cost of manufacturing
- Low additional costs for transport and erection
- Maintenance free

No impacts

- vibrations
- noise
- flickering / shade

Fundamental choices

AXIS: Horizontal (HAWT) or Vertical (VAWT) ?

- VAWT mechanically simpler
- aerodynamically more complex

ROTOR: Impulse type or aerodynamic ?

Impulse type (Savonius)

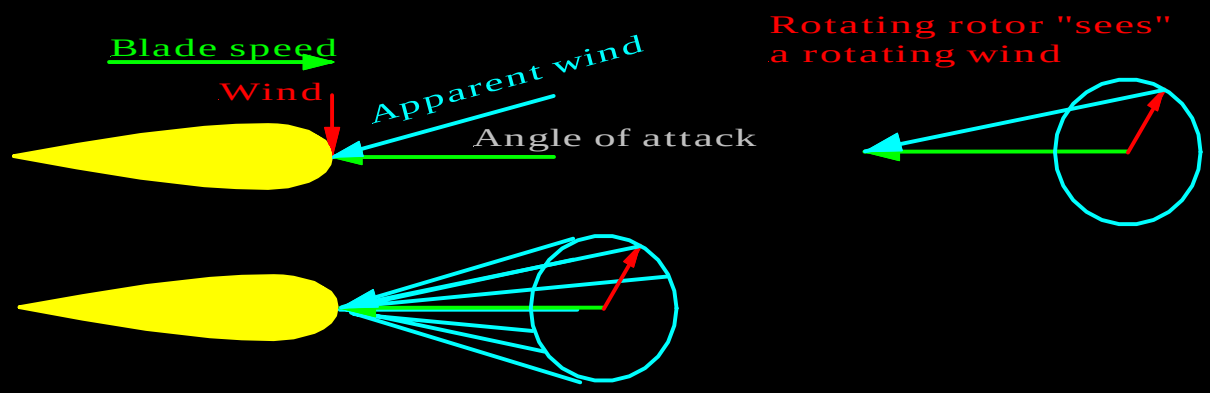
- extracts energy in the direction of the flow
- $\eta_{theoretical} < 19\ \%$

Aerodynamic (lift) type rotor

- extracts energy perpendicular to the flow
- $\eta_{theoretical} < 59\ \%$

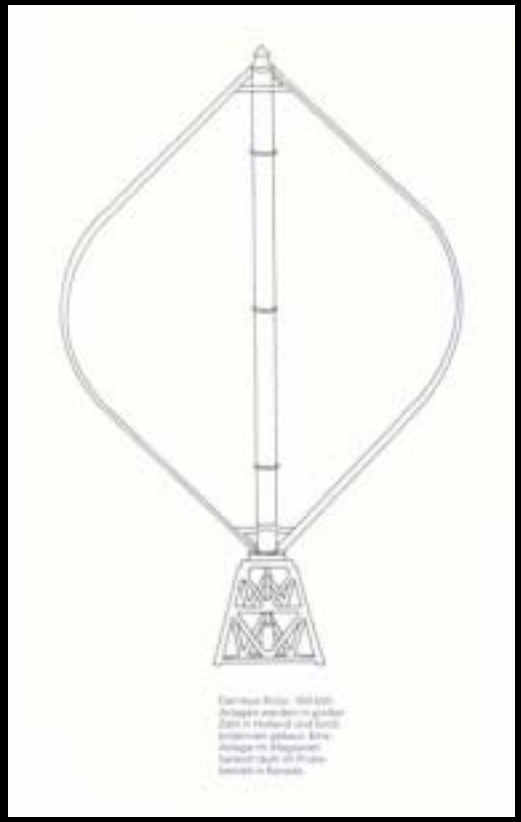
Turby is an aerodynamic VAWT

VAWT: Basic principle



- Angle of attack [Ŭ] :
  - *Blade speed (rotational speed x radius) & Wind speed*
  - *Ŭ < 15⁰ : ENERGY; Ŭ > 15⁰ STALL*
- To prevent stall: Blade speed > 3-4 x wind speed

The best known VAWT: Darrieus



- Rotational speed same over length of axis
- Radius varies
- Blade speeds varies

- Near shaft: STALL — vibrations
- In middle Ŭ å 0^0 — noise
- In between: lift — energy

- Little effective use of rotor surface

Turby's solution

- Constant radius
- Uneven number of blades
- Blades twisted to smoothen the effects change of wind direction

Turby meets design goals

Safety

- Survival wind speed > 55 m/s
- Kevlar inlay - blades may crack but will not shatter
- 2 independent brake systems / vibration control

Price / performance

- Good efficiency
- Few systems
- Easy transportation and installation
- Maintenance free

Impacts

- Nearly vibration free
- Noise level 70 dB(A) at 5 m distance
- Small blades matte finish

Yield

Available wind energy

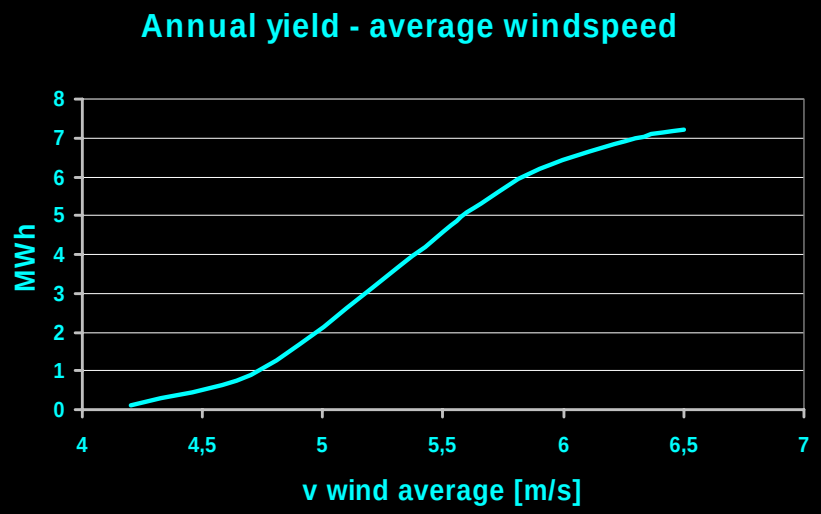
- Macro — average wind speed in the area
- Micro — roughness of the terrain
  - *height*
  - *increase in wind speed over obstacles*
  - *undisturbed wind flow from all directions*

Properties of the windturbine

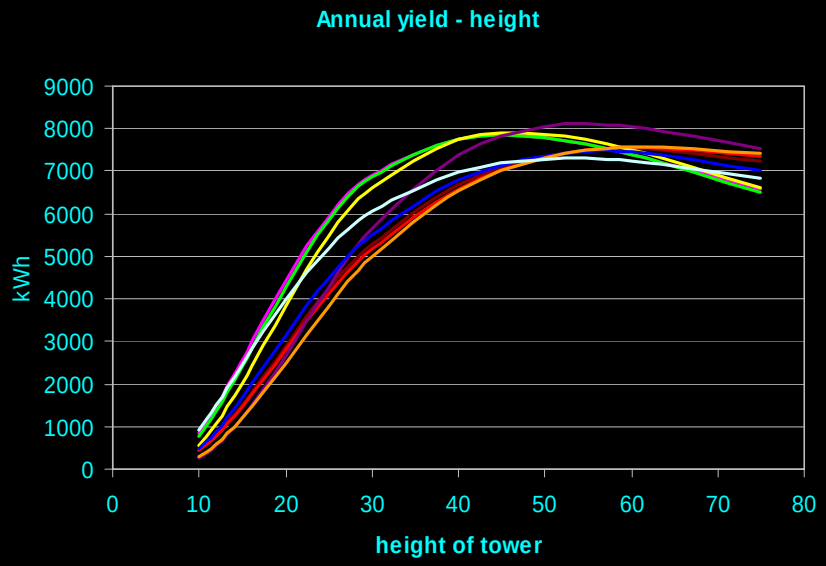
- Efficiency
- Suitability for local conditions
  - *turbulence*
  - *temperatures*
  - *snow and icing*

Yield II

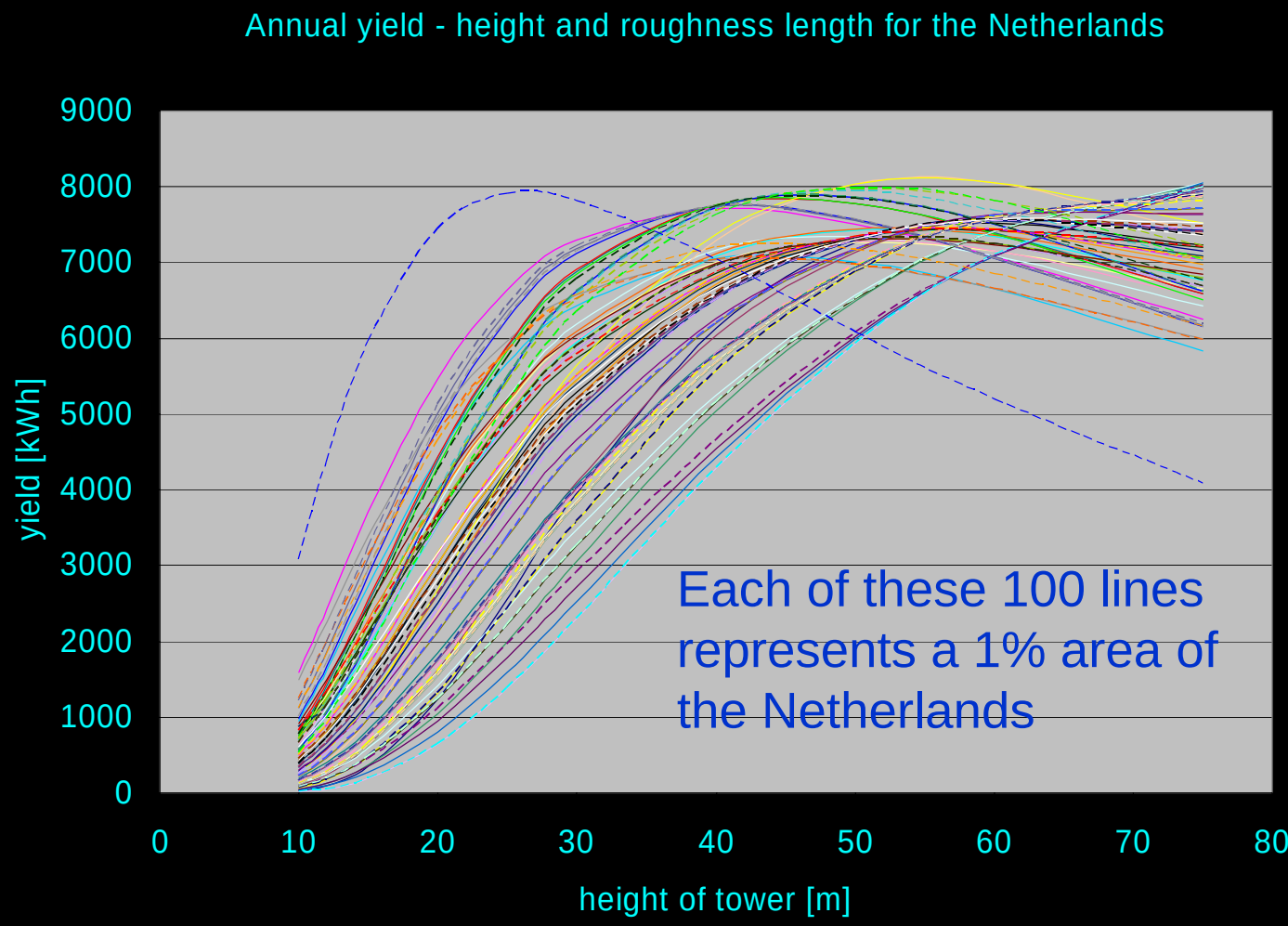
- Effect of average wind speed



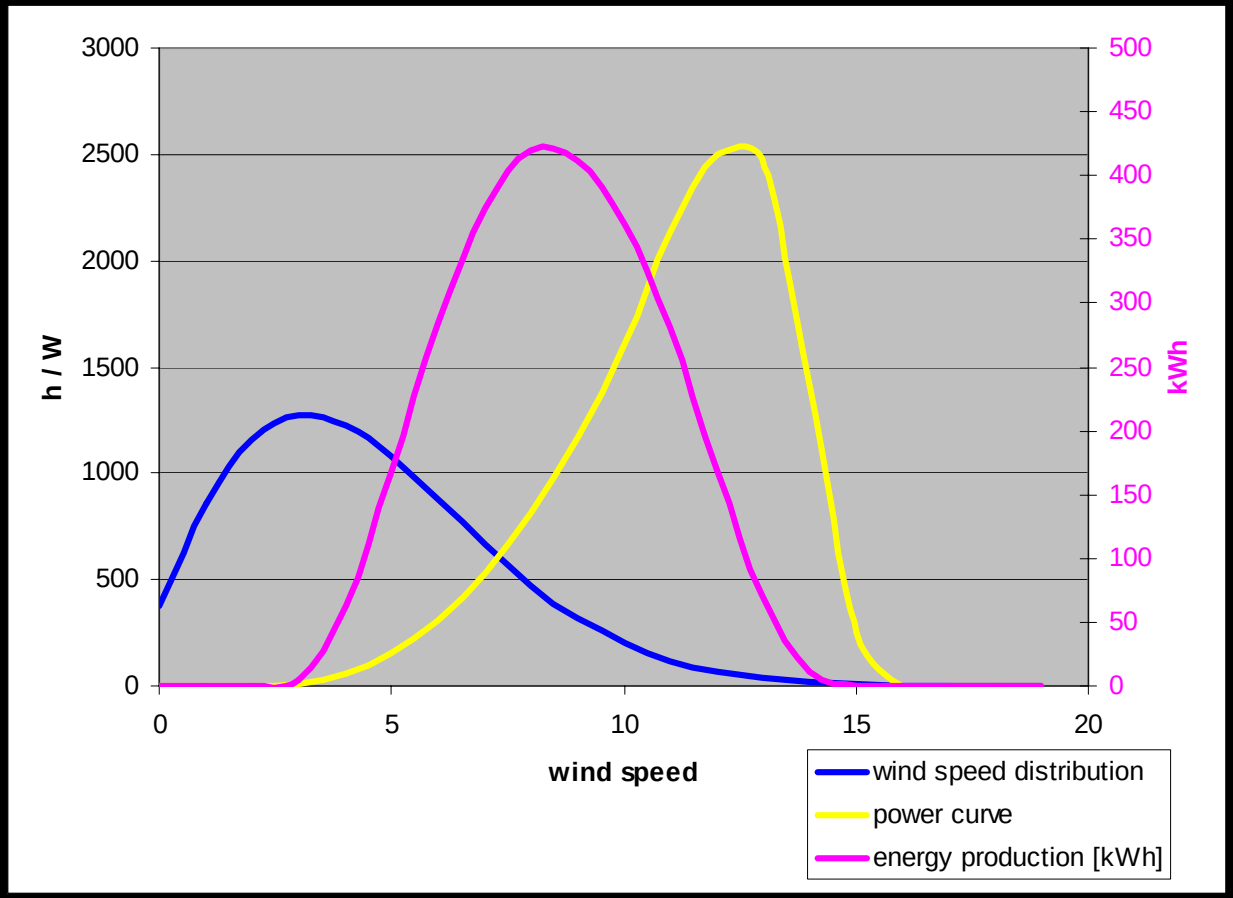
- Effect of height



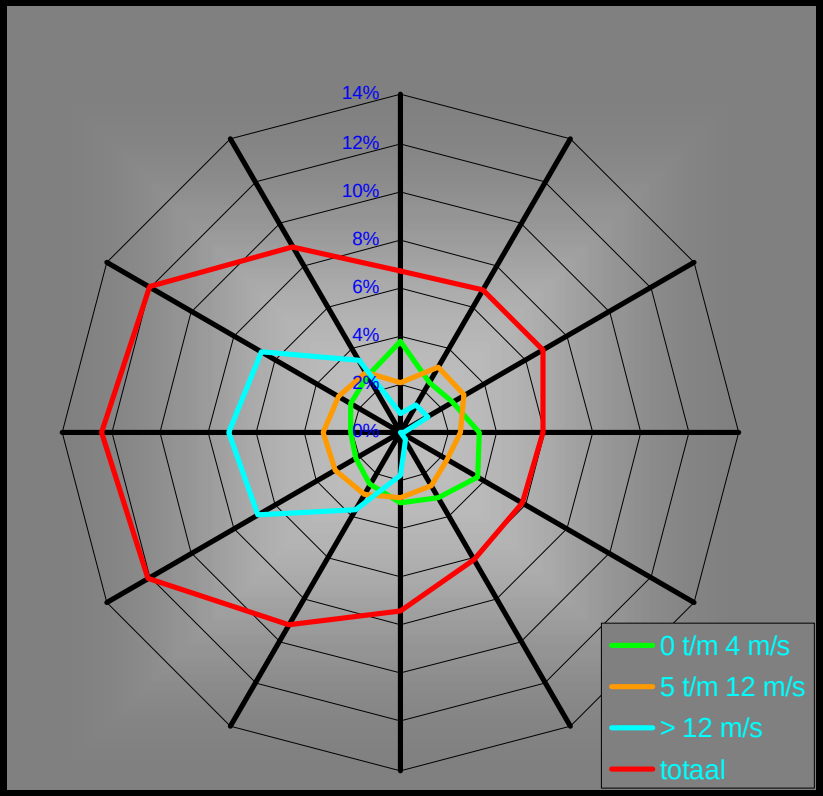
Yield varies with area and height



Wind speed range

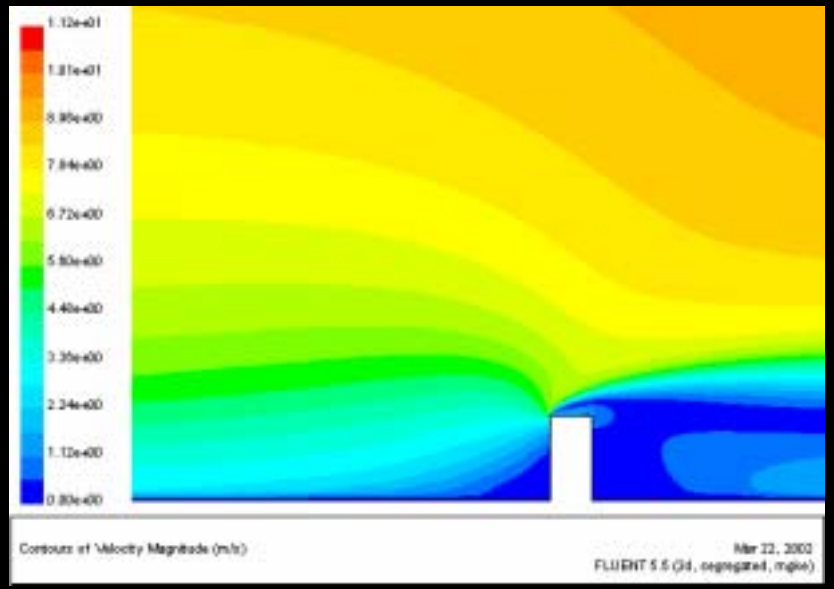


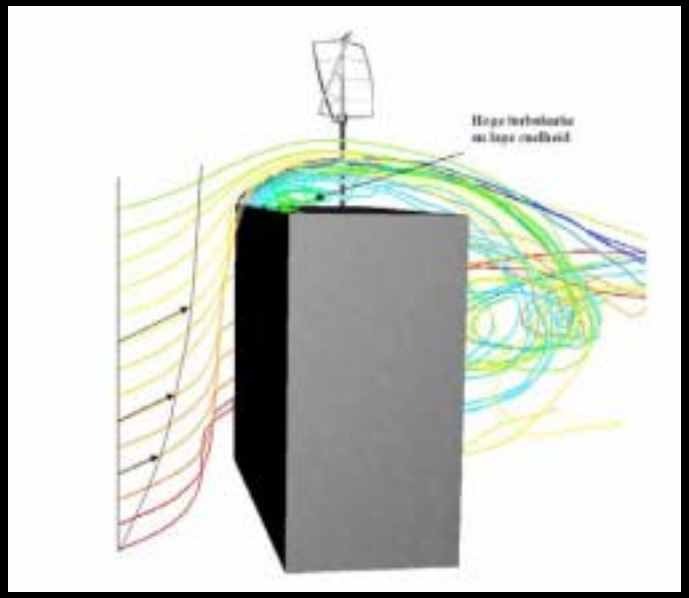
Effect of direction



A free flow from all sides is important

Wind over buildings

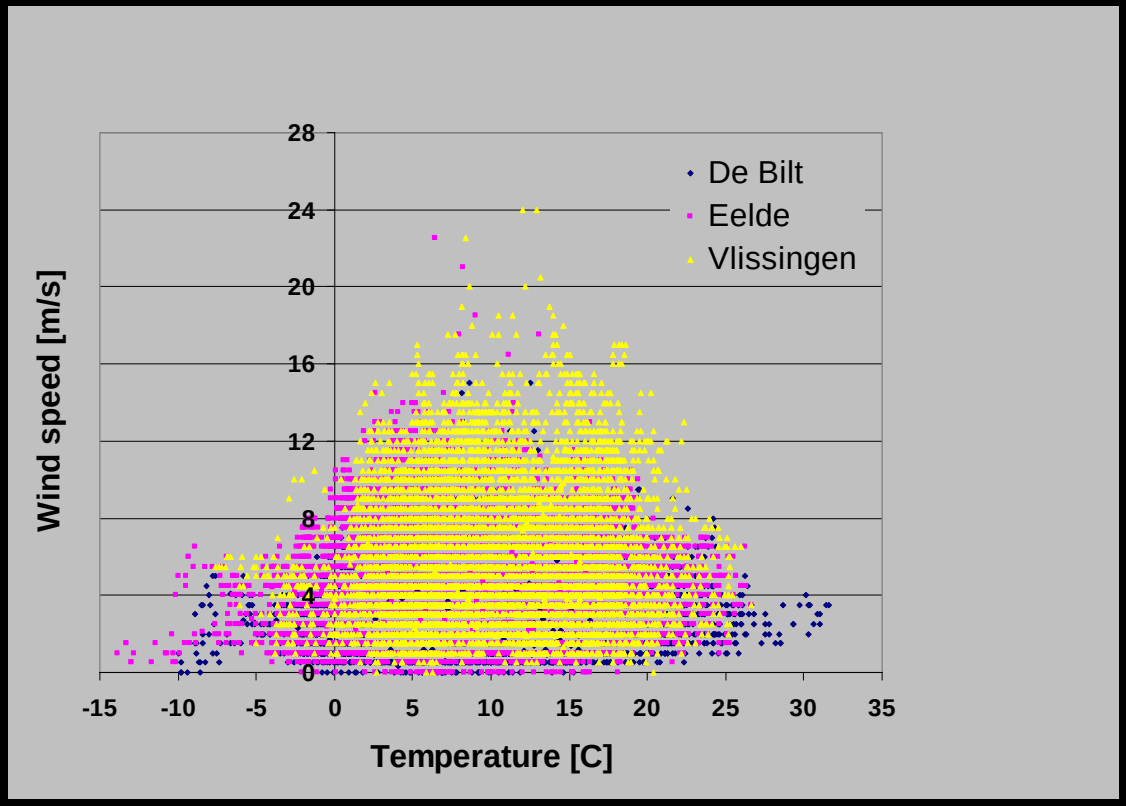




- above the roof.
- near centre of roof
- undisturbed flow from all sides

- Wind speeds 1,2 – 1,4 x higher! > 2 x more energy

Local conditions



Status

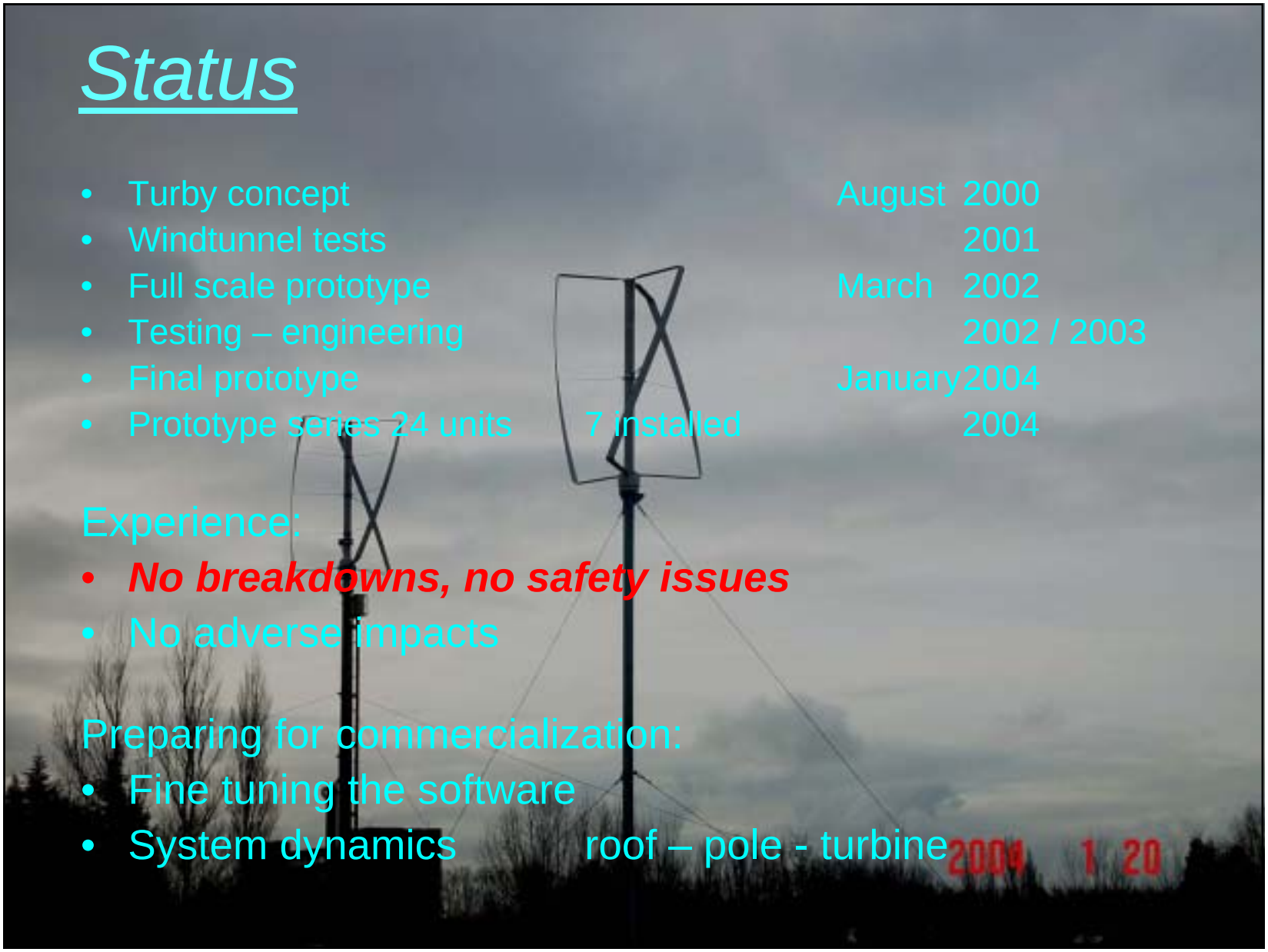
• Turby concept		August 2000
• Windtunnel tests		2001
• Full scale prototype		March 2002
• Testing – engineering		2002 / 2003
• Final prototype		January 2004
• Prototype series 24 units	7 installed	2004

Experience:

- ***No breakdowns, no safety issues***
- No adverse impacts

Preparing for commercialization:

- Fine tuning the software
- System dynamics roof – pole - turbine



A very early adapter


Number ONE
Ÿ Ŷ
2004 3 15

On the roof

Other installations

A computer representation