



Vaal University of Technology



**SANEA**

The South African National Energy Association  
Energy People Working Together

# High performance VAWT

Jan Jooste

Paul Krugman  
Nobel Prize Economics 2008  
*The Age of Diminishing Expectations*

Productivity isn't everything  
but in the long run it is almost everything



# Bill Gates: We need global 'energy miracles'

By John D. Sutter, CNN

February 12, 2010 8:03 p.m. EST



Bill Gates suggested researchers spend the next 40 years perfecting and implementing clean-energy technologies.



# Why?



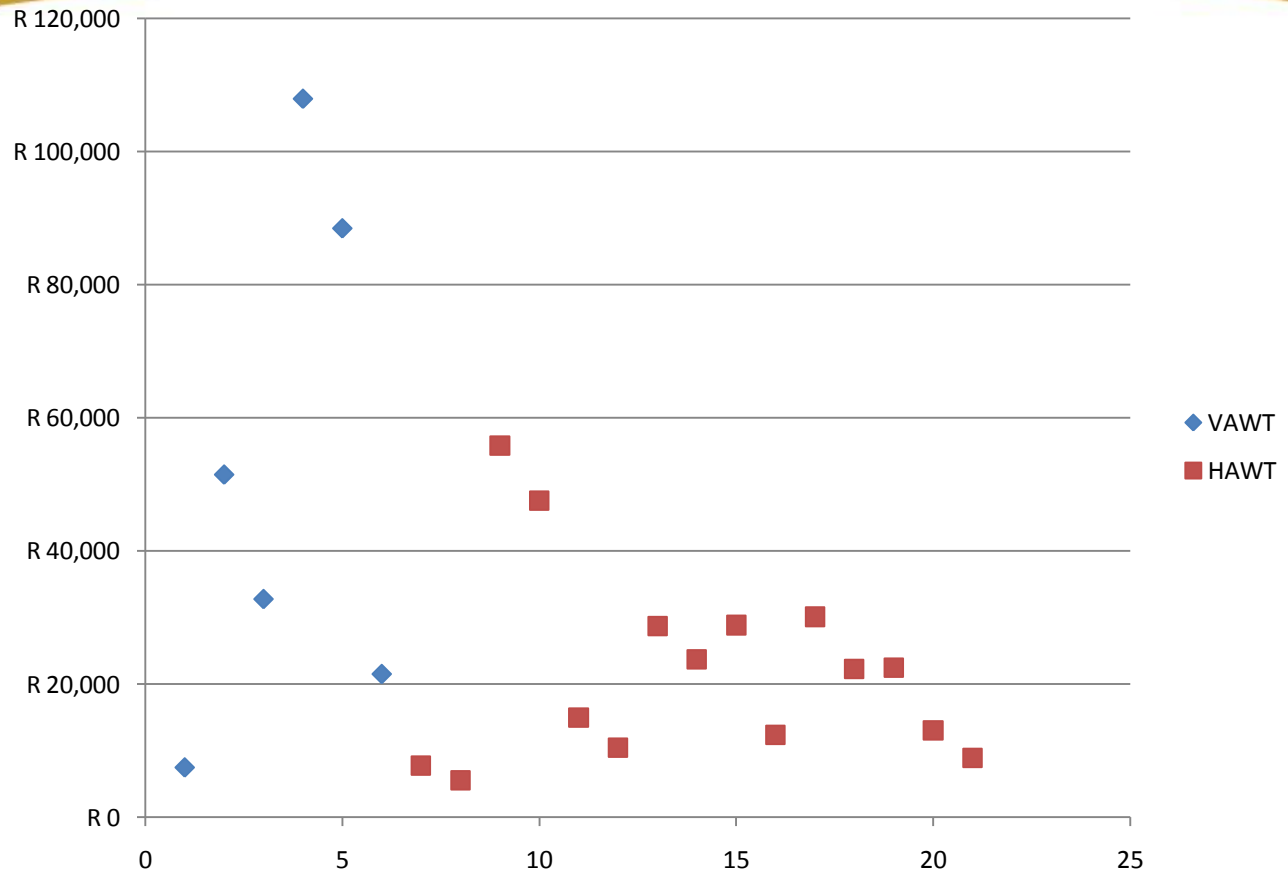
You see, for the last 25 years the world economy, the motor of the world economy that has been driving it was consumption by the American consumer who has been spending more than he has been saving, all right? Than he's been producing. So that motor is now switched off. It's finished. It's run out of — can't continue. You need a new motor. And we have a big problem. **Global warming. It requires big investment. And that could be the motor of the world economy in the years to come.**



# INTRODUCTION

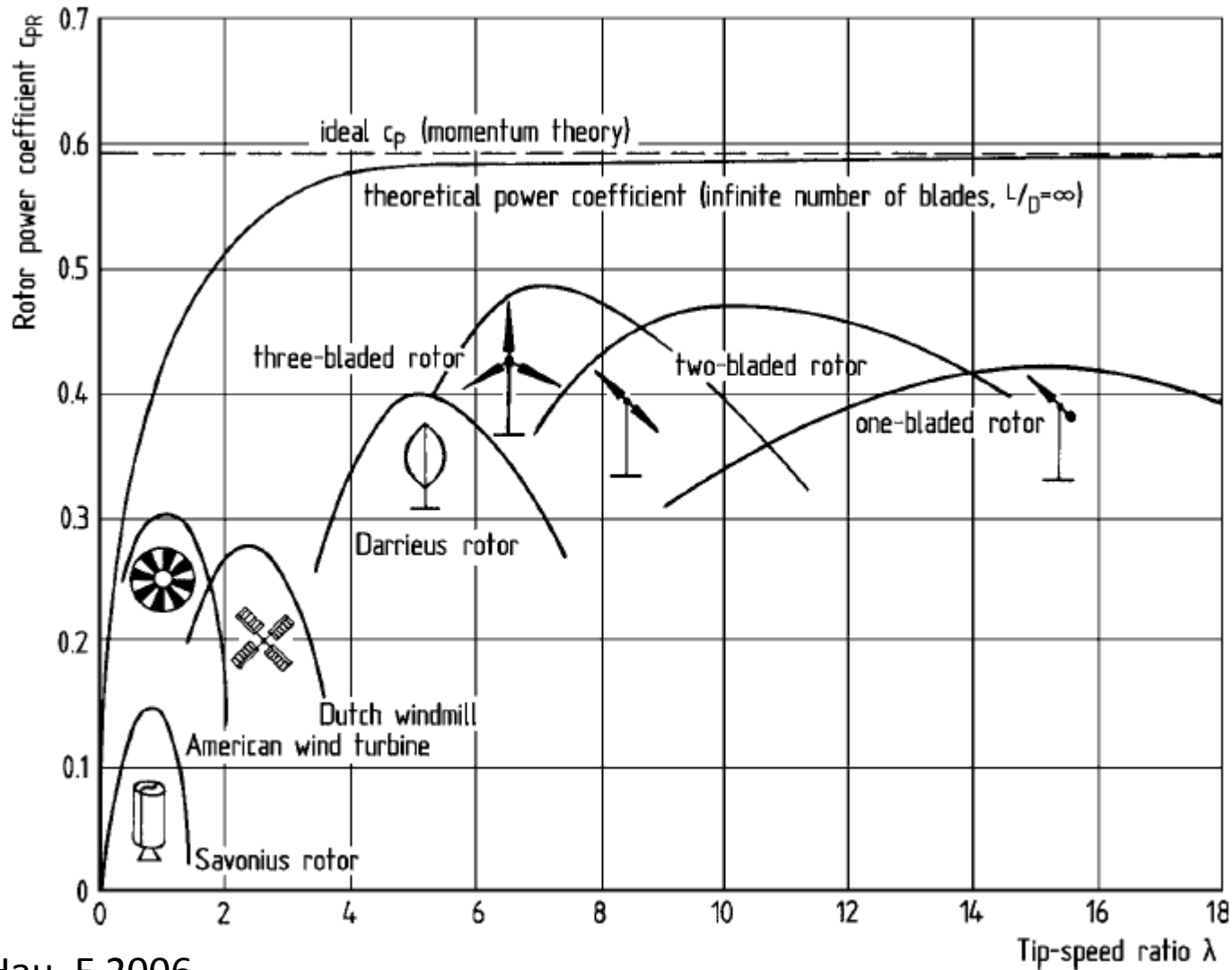
- Renewable energy harvesting highly dependent on R/kW capacity and R/kWh yield.
- Major research has been conducted to improve horizontal axis wind turbines.
- Nevertheless – still great reliance on subsidies.
- Vertical axis wind turbines might offer new opportunities to reduce cost.





VAWT R 51 634/kW - 233 %  
 HAWT R 22 196/kW - 100 %

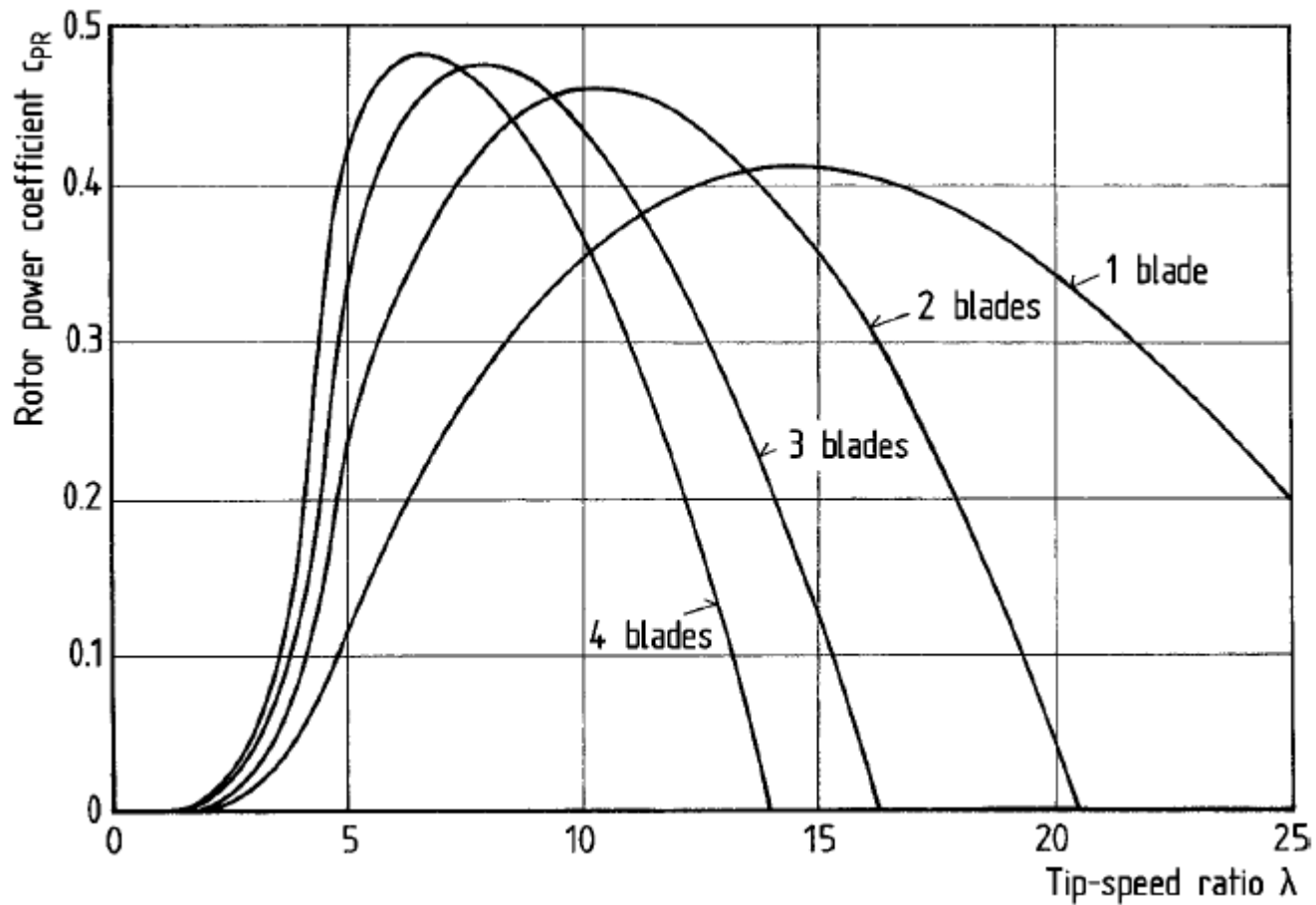




Hau, E 2006

*Wind turbines: fundamentals, technologies, application, economics*

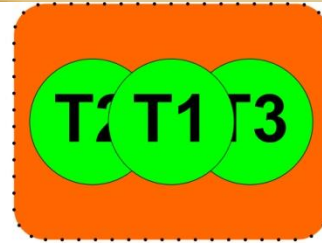
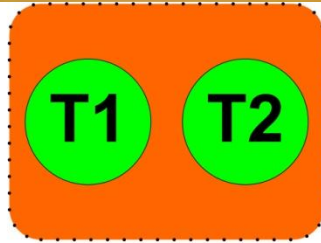
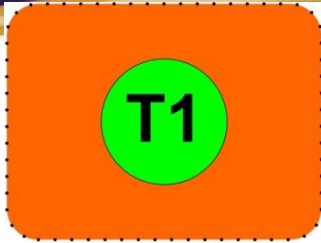




Hau, E 2006

*Wind turbines: fundamentals, technologies, application, economics*





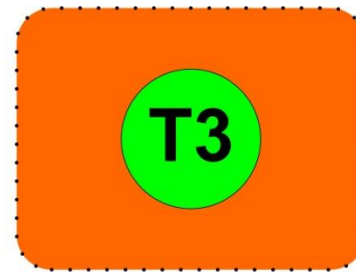
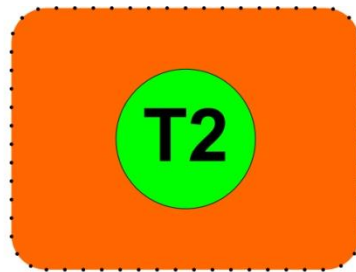
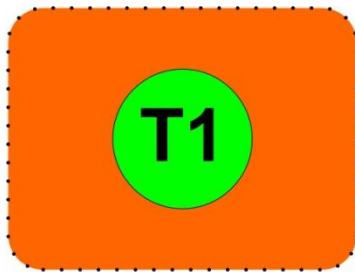
Case A

Case B

Case C

**Conventional configuration**





**High productivity configuration**





Conventional configuration



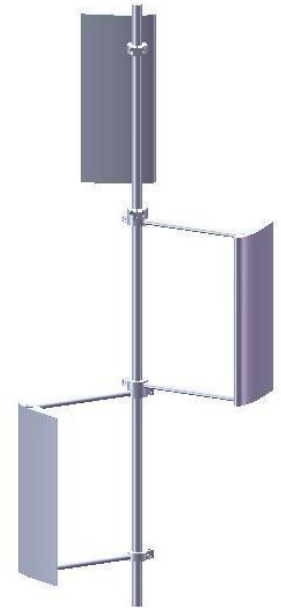
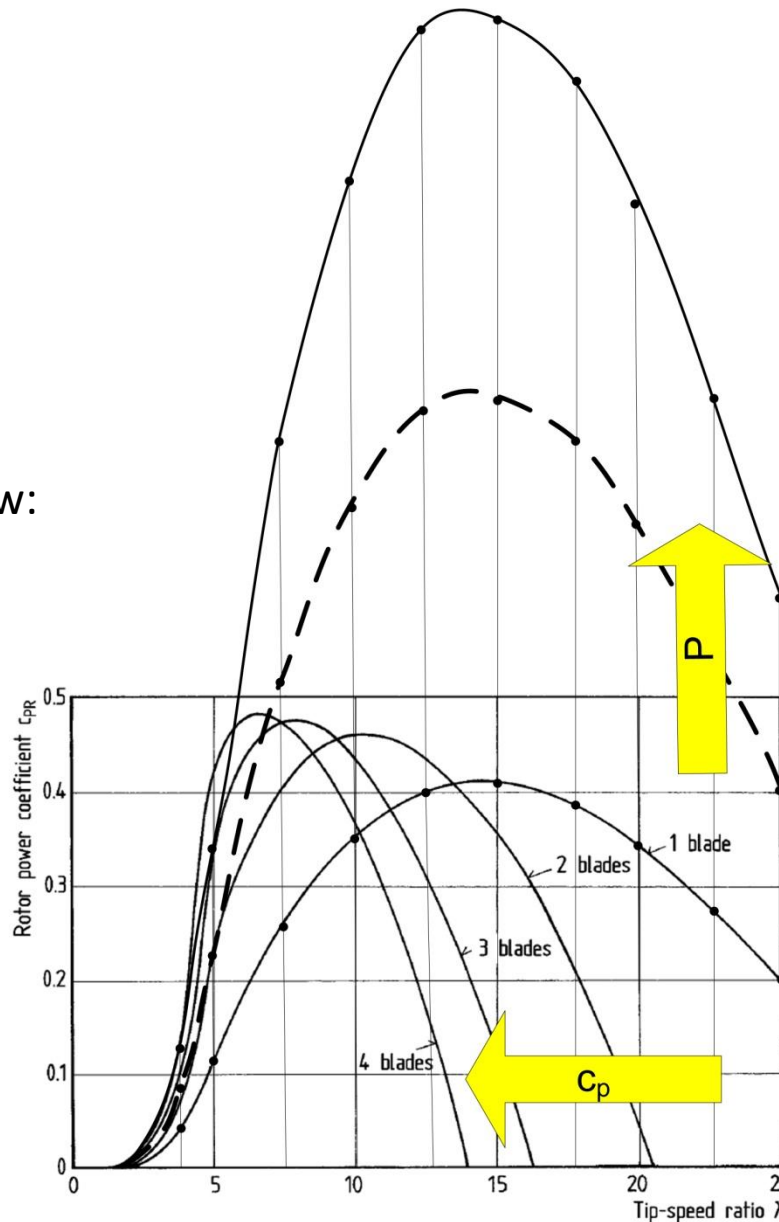
High performance configuration



Vertical axis now:

$$C_p * A$$

(A=1 for CT)



Adapted from  
Hau, E 2006  
*Wind turbines:  
fundamentals,  
technologies,  
application,  
economics*

Figure 5.29. Influence of the number of blades on the rotor power coefficient (envelope) and the optimum tip-speed ratio



# THEORETICAL IMPACT

- Increased power via increased area
- Back half empowerment
- Increased blade chord
  - => Higher Re
  - => Better lift/drag ratio

$$P_R = c_{PR} \frac{\rho}{2} v_W^3 A$$

where:

$A$  = swept area of the rotor ( $m^2$ )

$v_W$  = wind velocity (m/s)

$c_{PR}$  = rotor power coefficient (—)

$\rho$  = air density ( $kg/m^3$  at MSL)

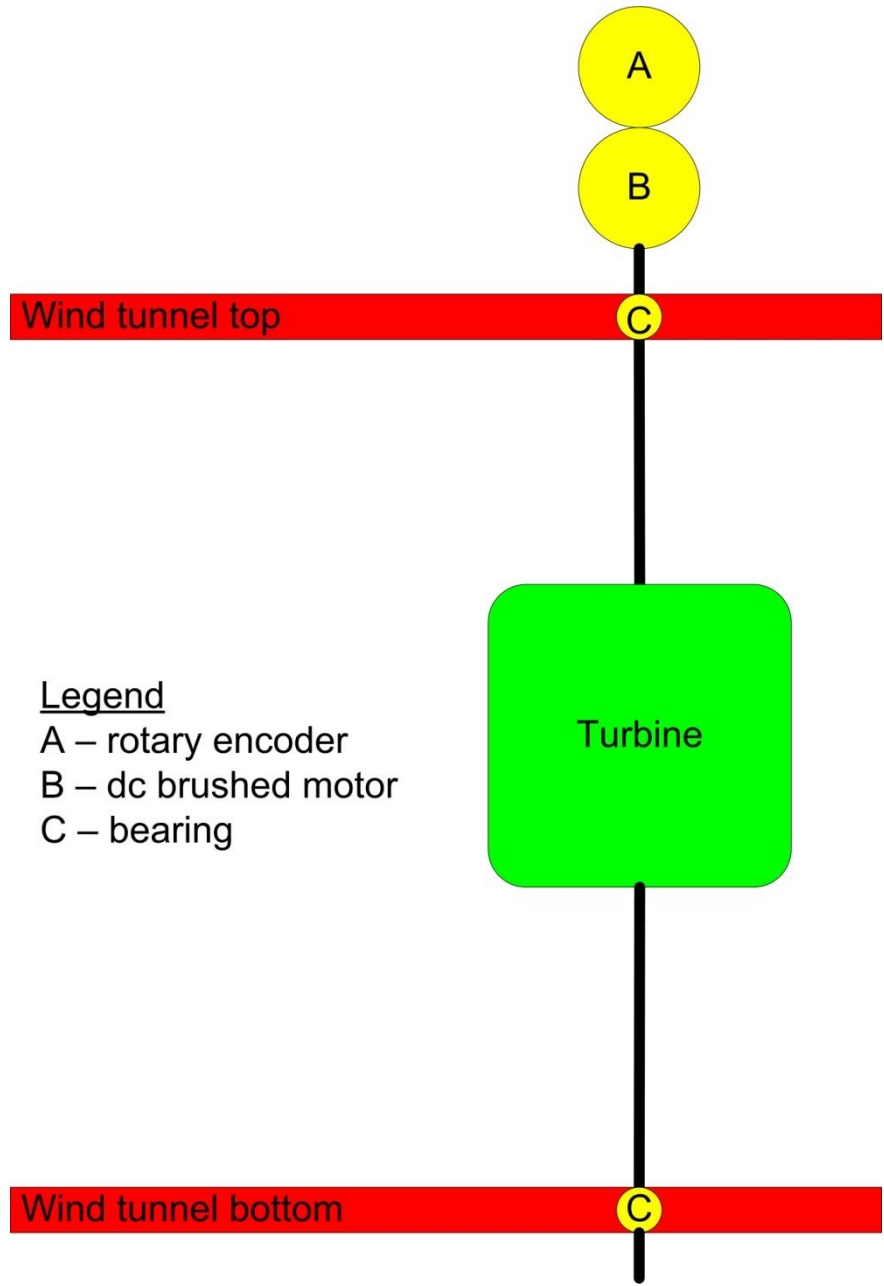
$P_R$  = rotor power (W)



# EXPERIMENT

- Wind tunnel
- Experimental modalities
  - Conventional configuration
  - High performance configuration
- Same incoming wind speed, density
- Unintended variances
  - Solidity
  - Tunnel blockage





Legend

- A – rotary encoder
- B – dc brushed motor
- C – bearing



## COMPARISON OF POWER VIA $V^2$

	No load	98,8 ohm	9.9 ohm	1,15 ohm
High performance turbine	1.637	0.359	0.019	0.000
Conventional turbine	0.314	0.089	0.003	0.000
<b>HPT/CT</b>	<b>522%</b>	<b>404%</b>	<b>667%</b>	<b>555%</b>



# ECONOMIC IMPACT

- HAWT vs HPWT
  - $C_p$
  - Upwards scalability
  - R/kWh
  - Manufacturability
- Coal and nuclear
  - Cost/kWh almost on par
  - Massive reduction wind
  - Ecological impacts



Gladwell, M 2000

*The tipping point: How little things can make a big difference*



# FUTURE RESEARCH

- CFD modeling
- Verify experimental results larger scale (0,14 m)
  - 0,6 m span blades
  - 3 m span blades
- Impact of vibration
- Impact of increased chord widths
- Long term performance (history)



Thank you

Questions?

