

Wind Turbine Control

C. Typical Control Approaches

1. Constant speed

b) Pitch regulated

PITCH ENABLES THE BLADE TO WORK CLOSE TO OPTIMALLY AT WIND SPEEDS BELOW CUT-OFF WIND SPEED



- VARY PITCH TO CAPTURE MOST ENERGY UP TO RATED SPEED (NOT ALWAYS DONE)
- VARY PITCH TO REDUCE TORQUE ABOVE RATED SPEED
- FEATHER TO STOP

THE BLADE OFTEN OPERATES NEAR $C_{L,max}$
SENSITIVE TO GUSTS, RPM CHANGES
DESIGN IS MORE COMPLEX

OPERATION

- DISENGAGE BRAKE
- PITCH BLADES TO (MAX) ROTATION

- PITCH BLADES TO SETTING FOR OPERATION
 - CONSTANT IN REGION II
 - VARYING IN REGION III

Wind Turbine Control

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2. Variable speed

MADE POSSIBLE BY
KEY BENEFITS POWER ELECTRONICS

- MACHINE OPERATES NEAR λ_{OPT}
- EFFECTS OF GUSTS HANDLED WITH

a) Stall regulated INCREASING Ω

POWER ELECTRONICS REGULATE
GENERATOR TORQUE

CUT-IN SPEED \rightarrow VARIABLE SPEED OPERATION TO
MAXIMIZE $C_p \rightarrow$ CONTINUES UP
TO MAXIMUM Ω

BELOW RATED POWER \rightarrow FIXED SPEED OPERATION

ABOVE RATED POWER \rightarrow ROTOR SPEED & STALL
USED TO CONTROL TORQUE
 \rightarrow SLOW λ PROMOTES STALL

OPERATION \rightarrow SIMILAR TO CONSTANT SPEED, STALL REGULATED

DYNAMIC CONTROLLER MANAGES GENERATOR TORQUE &
PITCH RATE



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2. Variable speed

b) Pitch regulated

BOTH ROTOR SPEED (GENERATOR TORQUE)
& BLADE PITCH AS CONTROL MEANS

BELOW RATED
WIND SPEED

BLADE PITCH FIXED
ROTOR SPEED VARIES TO
MAXIMIZE λ

RATED WIND
SPEED & ABOVE

GENERATOR TORQUE
USED TO MAINTAIN POWER

BLADE PITCH USED TO MAINTAIN ROTOR SPEED
WITHIN LIMITS

GUSTS HANDLED BY ALLOWING ROTATION SPEED TO INCREASE
DEMAND ON PITCH SYSTEM IS LOWER THAN ON
FIXED SPEED MACHINE

DYNAMIC CONTROL NOW CONTROLS BLADE PITCH &
GENERATOR TORQUE



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3. Examples

- a) NEG-Micon 750
 - Stall Regulated
 - Constant Speed



REDUCED PERFORMANCE
AT HIGHER WIND
SPEEDS TYPICAL OF
THIS CLASS OF TURBINE



Wind Turbine Control

C. Typical Control Approaches

3. Examples

- a) Siemens SWT-1.3
 - Stall Regulated
 - Variable Speed



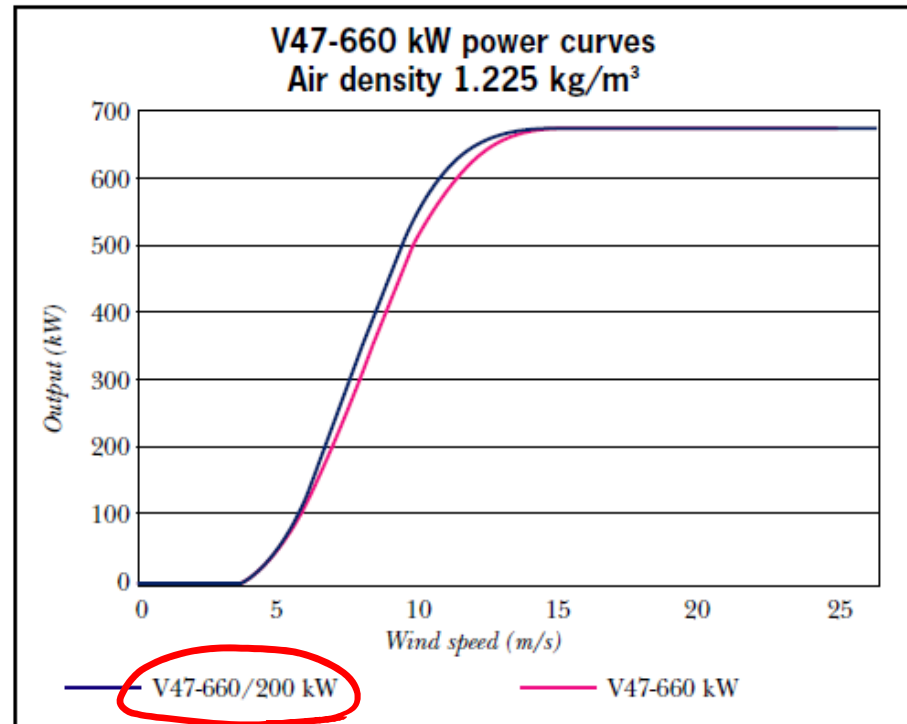
Wind Turbine Control

C. Typical Control Approaches

3. Examples

a) Vestas V47

- Pitch Regulated
- Constant Speed



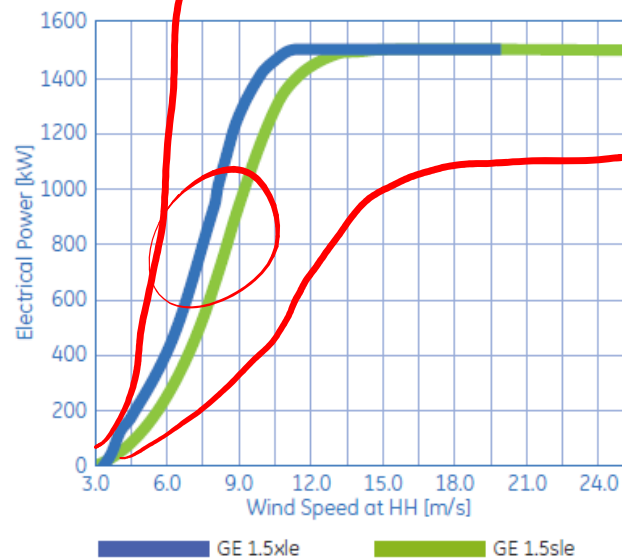
Wind Turbine Control

C. Typical Control Approaches

3. Examples

a) GE 1.5 SE

- Pitch Regulated
- Variable Speed

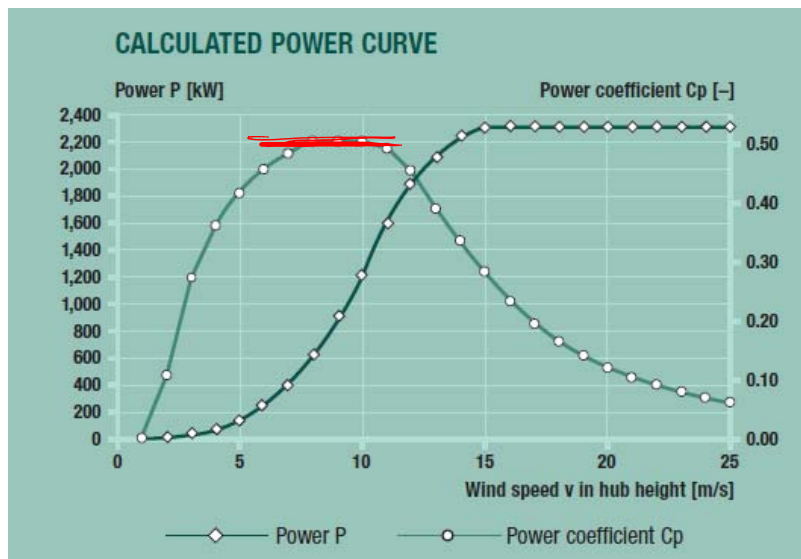


Wind Turbine Control

C. Typical Control Approaches

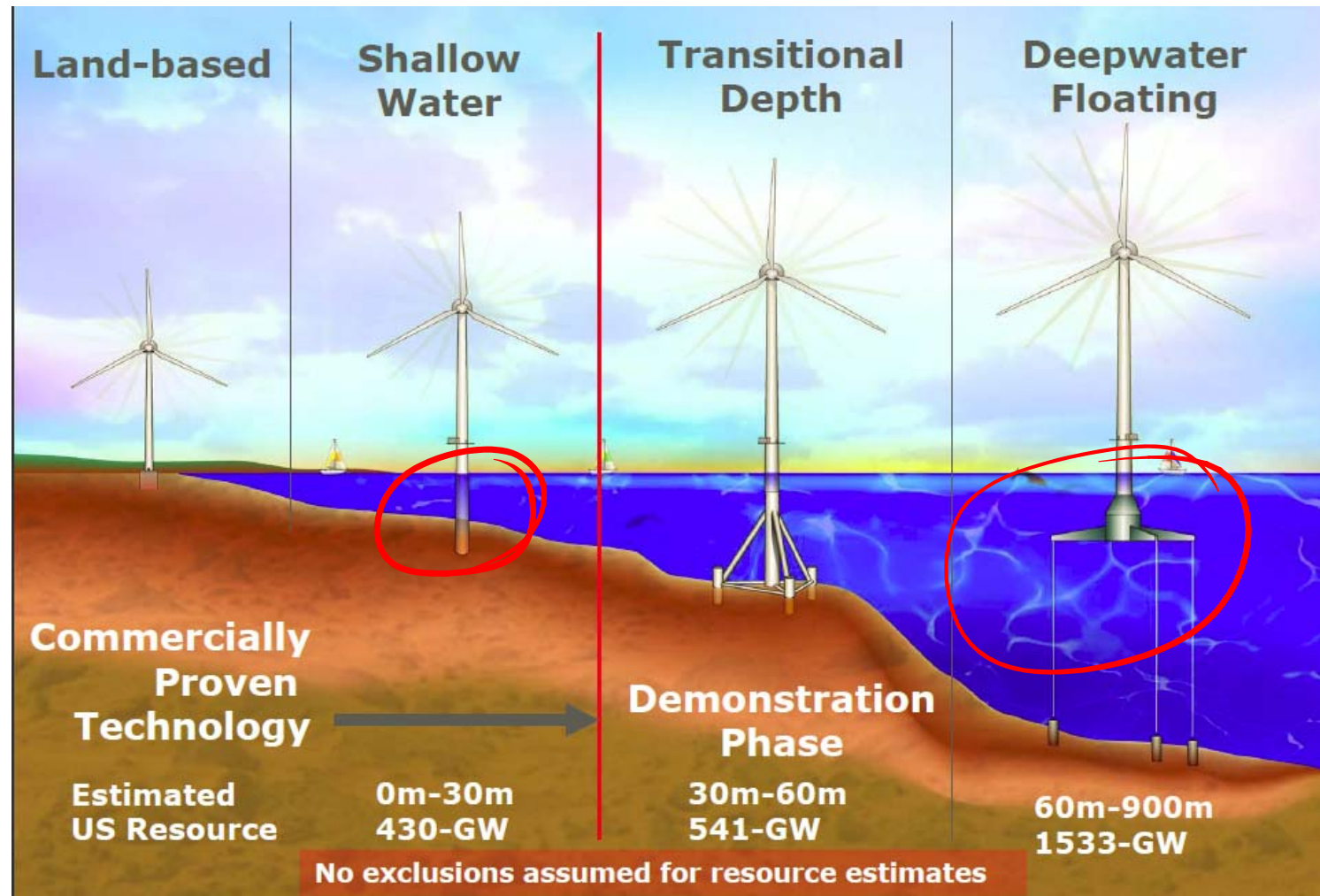
3. Examples

- a) Enercon E70/2300
- Pitch Regulated
 - Variable Speed
 - Direct Drive



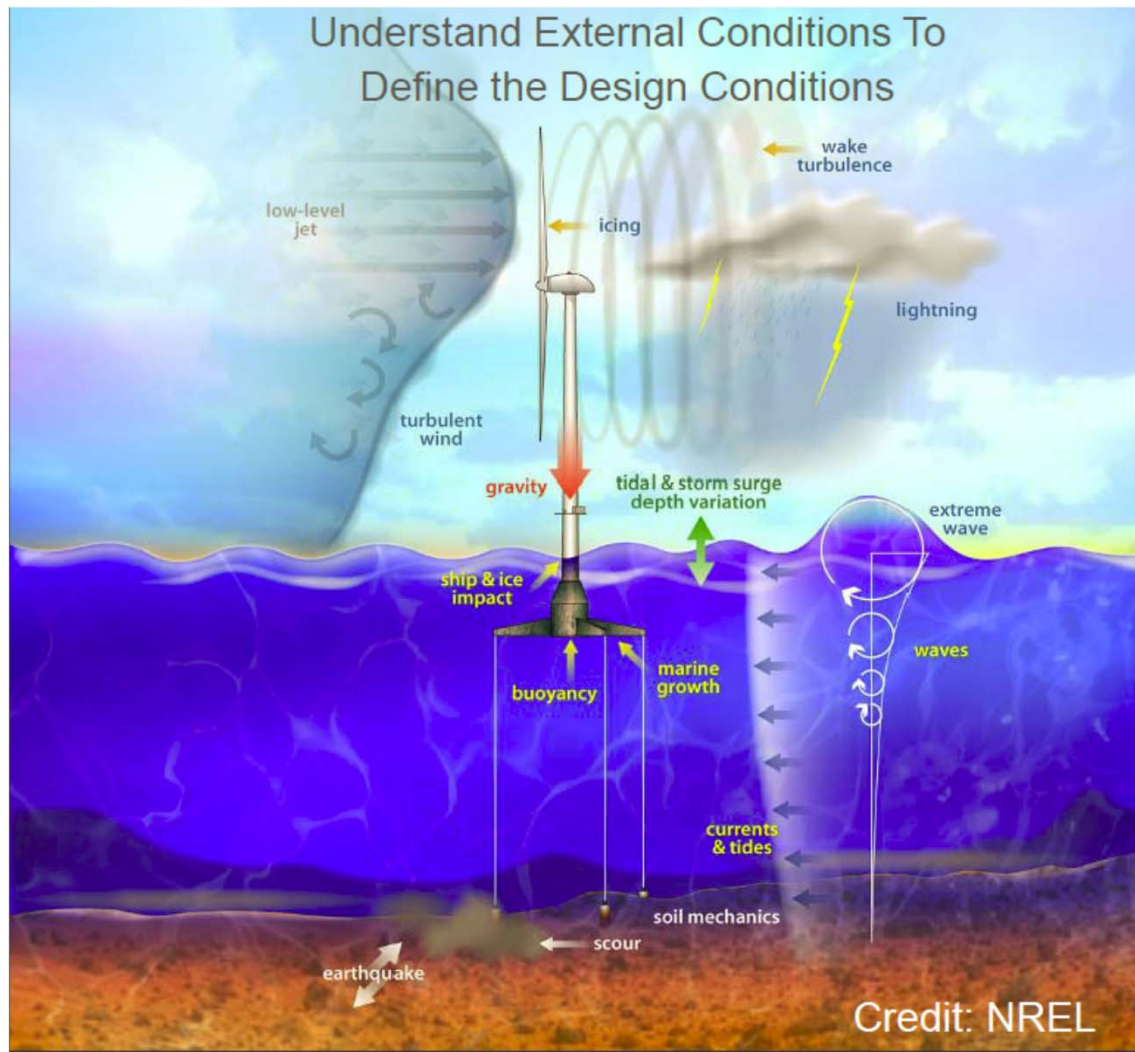
Wind Turbine Control

D. New Challenges for Wind Turbine Control



Wind Turbine Control

D. New Challenges for Wind Turbine Control



OFFSHORE

WIND PLANT
CONTROL