Energy and Environment Science

Unit – 3 : Wind Energy Syllabus:

i. **Power and energy from wind turbines**
ii. **Wind energy theory and Fundamentals**
iii. **Types of wind turbines**
iv. **Offshore Wind energy**
v. **India's wind energy potential**
vi. **Environmental benefits and impacts.**

Class 3

- ✓Wind power Potential in India
- ✓Applications,
- ✓Advantages, disadvantages,
- ✓Cost Economics
- ✓ENVIRONMENTAL ASPECTS

Wind power Potential in India

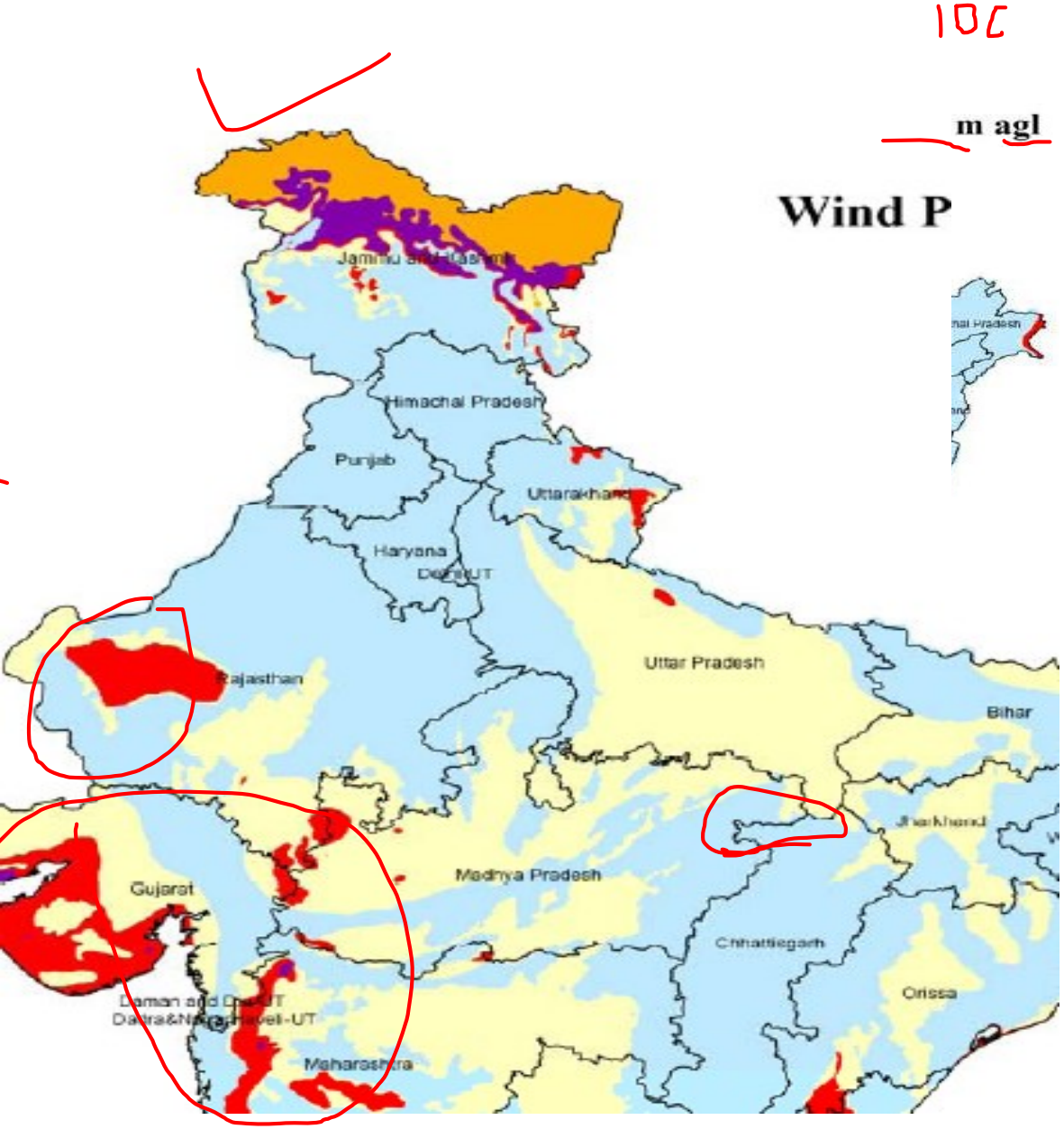
- The country's wind power potential at 100 m above ground level is 302 GW.
- The Indian wind industry is on track to achieve the government's 60 GW wind capacity target ahead of the 2022 deadline as it has already crossed 34 GW.

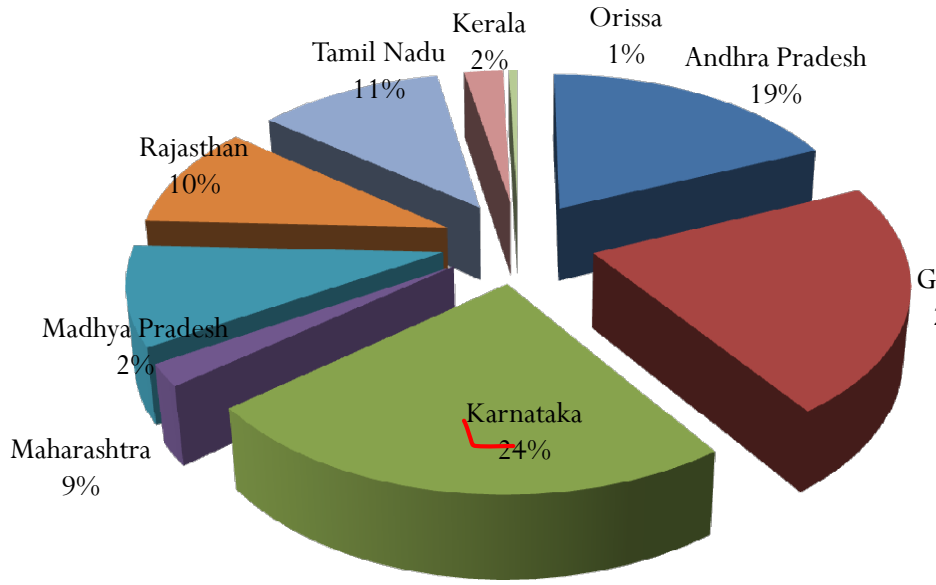
Wind energy sector **contributes to the country** by

- generating employment,
- reducing the adverse effects of greenhouse gases
- and increasing the size of gross domestic product.

- Wind power generation capacity in India has **significantly increased in recent years**.
- As of 28 February 2021, the total installed wind pow capacity was 38.789 GW, the **fourth largest installed wind power capacity in the world**
- Wind power costs in India are decreasing rapidly.
- The levelised tariff of wind power reached a record lo of ₹2.40 per kWh (without any direct or indirect subsidies)

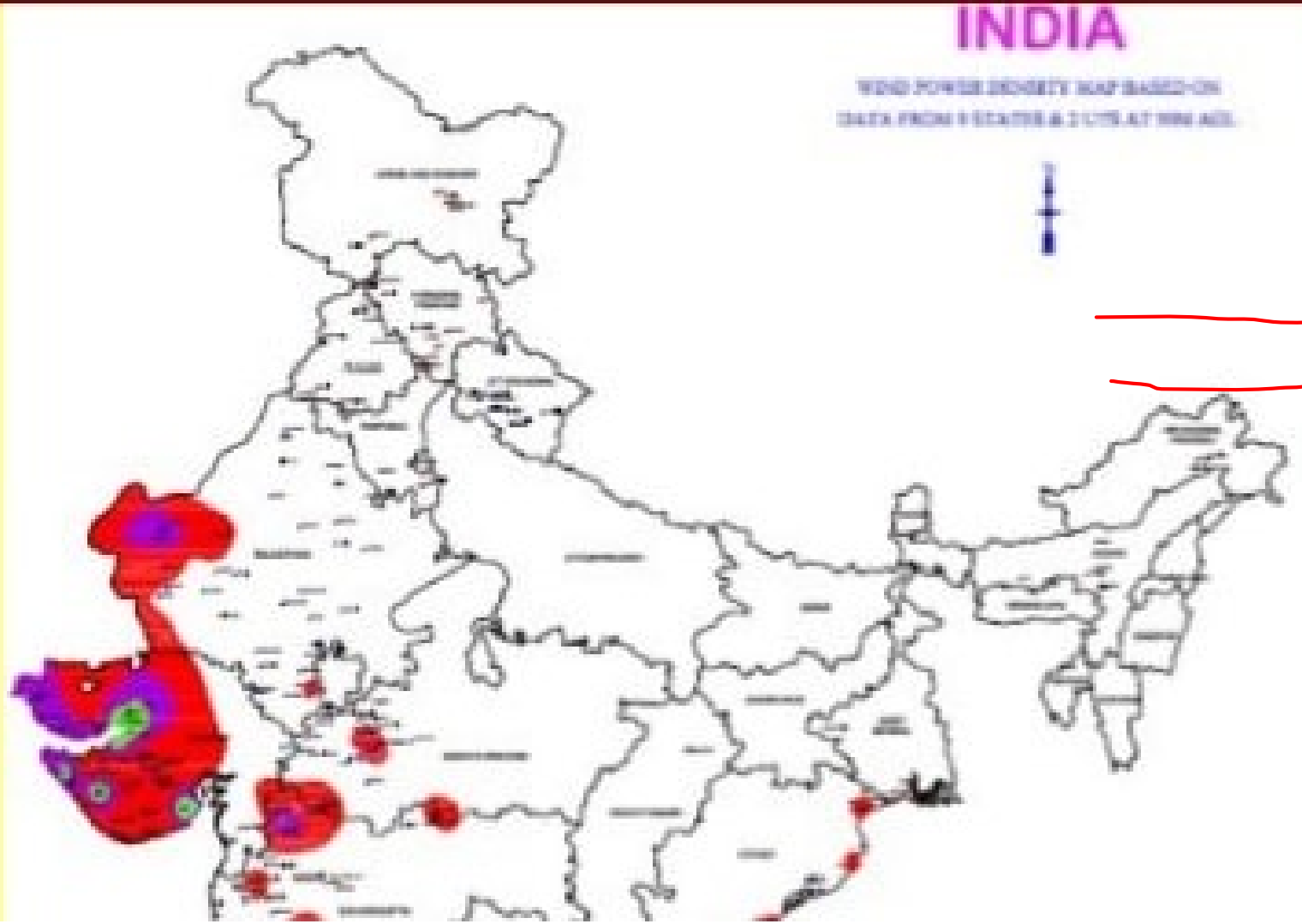
Power Potential





State Wise -Wind potential in India		
Sl.No.	Sources	Potential i
1	Andhra Pradesh	8968
2	Gujarat	10645
3	Karnataka	11531
4	Madhya Pradesh	1019
5	Maharashtra	4584
6	Rajasthan	4858
7	Tamil Nadu	5530
8	Kerala	1171
9	Orissa	255
Total		48561

Wind Power Poten



The
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stat
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is a

nstalled wind capacity by state as of 31 October 2019[1]

State	Total Capacity (MW)
Tamil Nadu	9231.77
Gujarat	7203.77
Maharashtra	4794.13
Karnataka	4753.40
Rajasthan	4299.73
Andhra Pradesh	4077.37[28]
Madhya Pradesh	2519.89
Telangana	128.10
Kerala	62.50
Others	4.30
Total	**37090.03**

Installed Wind Power Capacity	
Fiscal	Year End Cumulative Capacity (in MW)
2005	6,270
2006	7,850
2007	9,587
2008	10,925
2009	13,064
2010	16,084
2011	18,421
2012	20,149
2013	21,264
2014	23,354
2015	26,769
2016	32,280
2017	34,046
2018	35,626
2019	37,669
2020	38,785

nil Nadu

nil Nadu's wind power capacity is around **29% of India's total**
Government of Tamil Nadu realized the importance and need
renewable energy, and set up a separate Agency, as registered
iety, called the Tamil Nadu Energy Development Agency (TEDA
arly as 1985. Tamil Nadu is a leader in Wind Power in India.

Muppandal **windfarm** **the total capacity is 1500 MW**, the large
d power plant in India.
total wind installed capacity in Tamil Nadu is 7633 MW

harashtra is one of the prominent states that installed wind po
ects second to Tamil Nadu in India.

he major manufacturers of wind turbines including ReNew
er, Suzlon, Vestas, Gamesa, Regen, Leitner Shriram have prese
Maharashtra.

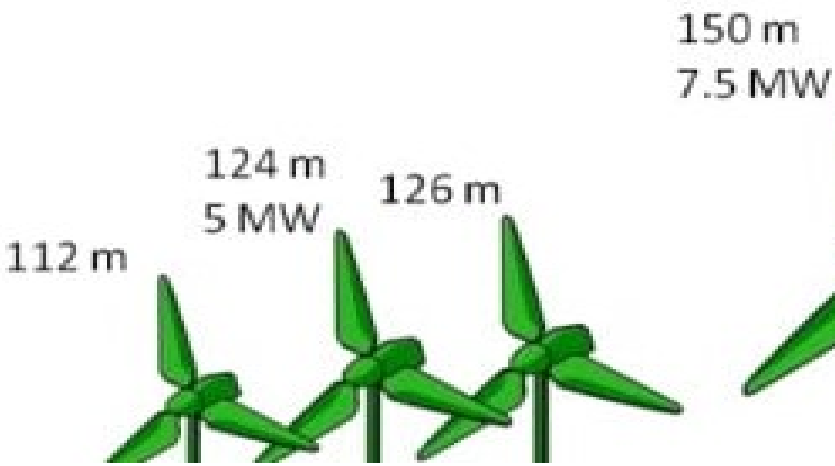
arat

arat government's focus on tapping renewable energy has led
rp rise in the wind power capacity in the last few years. Accord
fficial data, wind power generation capacity in the state has
eased a staggering ten times in the last six years.
arat has 16% of total capacity of country.

Timeline of Size and Ca
of Wind Turbines

The power transferred to generator (P) is directly proportional to the rotor surface area (A)!

$$P \propto A$$



Future of Wind Power in In

Year	Wind Energy Installed Capacity in MW (Aggressive Scenario- Theoretical Possibility)	Wind in
2020	54602	
2025	108835	
2030	221080	

WIND ENERGY POTENTIALS OF I

- The National Institute of Wind Energy, fo
  Energy Technology, recently announced t
  energy potential in the country is 302 GW (
  of 100 meters).
- The fresh estimates are six-times the wind
  at a 50 meter hub height, and three-times
  hub height of 80 metres.
- Of the total estimated 302 GW potential
  wasteland, 146 GW in cultivable land, and
  2015)
- "The new Berkeley Lab study has found the

The Future of Wind - O

Wind Energy Applications

1. Electricity Production

2. Wind Energy for Water Applications

- ✓ Water Pumping

3. Industrial Applications

- ✓ Telecommunications
- ✓ weather stations

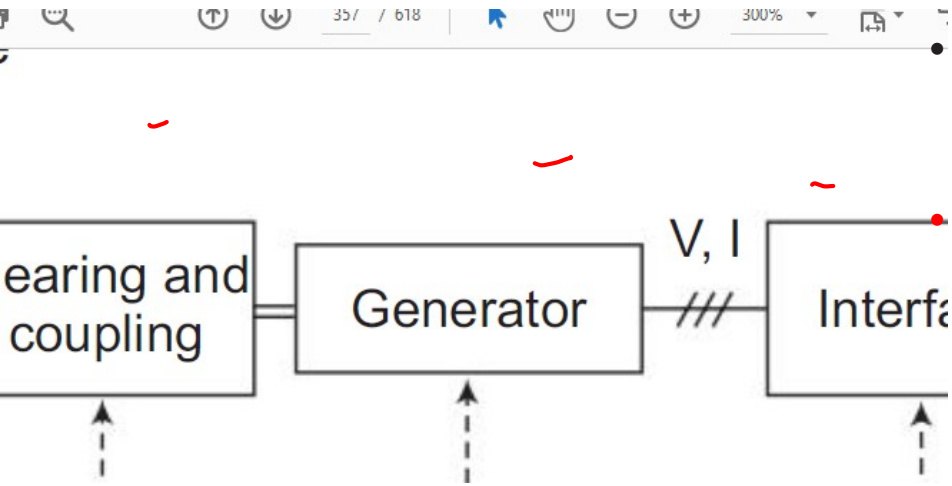
4. windmill

Wind Energy Applicati

- Wind Energy For Water applications
- For hydropower Applications
- Wind energy for generation of electricity

WIND SYSTEMS

WIND ENERGY CONVERSION SYSTEMS (WECS)



wind energy conversion tem converts wind energy o some form of electrical ergy.

synchronous or induction erators are used for mechanical electrical power conversion ending on the design of the em.

Main features of various types of generators and thei in wind power generation are discussed below:

- (a) DC Generator Conventional dc generators are no more due to their high cost, weight and maintenance problems commutator. However, permanent magnet (brush less and commutator less) dc machines are considered in small rat hundred kW) isolated systems.
- (b) Synchronous Generator Synchronous generators produ quality output and are universally used for power generat conventional plants. However, they have very rigid require maintaining constant shaft speed and any deviation from synchronous value immediately reflects in the generated f
- (c) Induction Generator Primary advantages of induction m the rugged, brush less construction, no need of separate d power and tolerance of slight variation of shaft speed (±10 as these variations are absorbed in the slip. Compared to synchronous machines they have low capital cost, low ma and better transient performance.

WIND ENERGY CONVERSION SYSTEMS (WECS)

Based on the generator drive, two schemes have been developed for the operation of WECS:

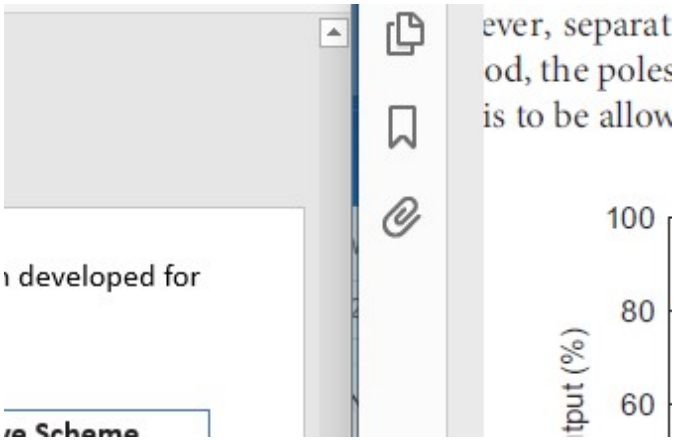
- (i) fixed speed drive scheme and
- (ii) variable speed drive scheme.

ixed Speed Drive Scheme

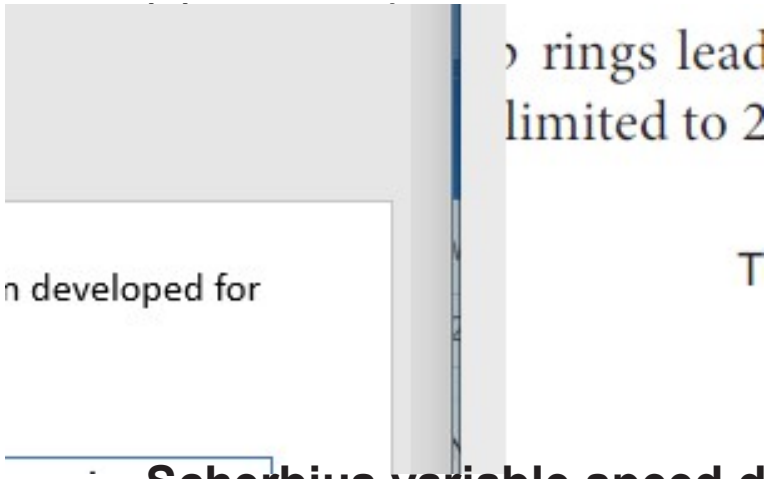
(a) One Fixed Speed Drive

(b) Two Fixed Speed Drive

- **Variable Speed Drive Scheme**
  - (a) Variable Speed Drive Using Power Electronics
  - (b) Scherbius Variable Speed Drive
  - (c)



Power output vs wind speed for two fixed speed drives

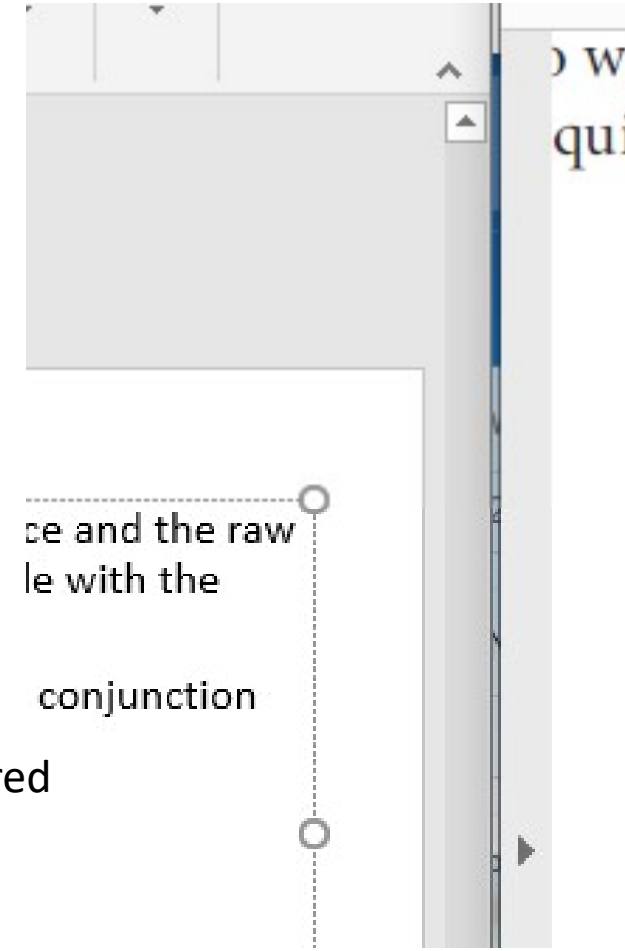


Scherbius variable speed drive

WIND–DIESEL HYBRID SYSTEM

ortunately, wind is a highly fluctuating power
rce and the raw output at the terminals of a
d turbine is incompatible with the demand of
rmal domestic or commercial user.

uch places isolated wind turbines can be
alled in conjunction with diesel generating
s for backup.



es of operational schedule is possible for diesel unit:

nuous Diesel Unit Operation

simplest way to incorporate the wind turbine into the standard diesel powered
em, without increasing the risk of loss of load, is to operate wind turbine in
llel with a continuously running diesel generator.

ittent Diesel Unit Operation

his mode diesel unit is switched off during periods when the output of wind
bine is sufficiently high to meet the demand without any backup. The saving in
is more in this case.

EFFECTS OF WIND SPEED AND GRID CONDITION (SYSTEM INTEGRATION)

A utility has to serve the varying load of its customers by the power available fror various power plants.

As wind power is a varying power source, which cannot really b dispatched, conventional power plants or storage facilities have to deal with thes variations.

If the penetration of wind power into the grid is continuously increased, it might reach t a level where economics of the total power production is affected in a negative way. Thi will limit the penetration of wind power into the grid.

The optimum penetration depends on specific circumstances and characteristics of th utility system.

In most cases wind power penetration level less than 10 per cent of the total electricit production will cause no severe problem and will not cause any economic disadvantage.

For higher penetration, total electricity production system is to be re-optimized. This ma require integration of some more peak load units or storage capacity plants.

Also the distance of the wind resource from the grid poses another limiting factor as i influences the economics of wind power.

A distance of less than 50 km is generally considered as economically feasible.

WIND ENERGY STORAGE

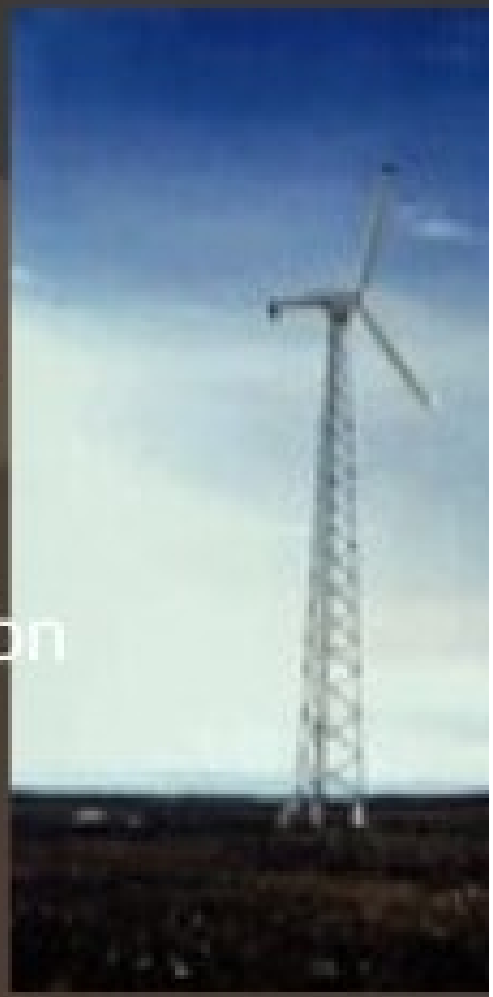
place of a generator, a compressor is used in the nacelle.
he highly compressed air is sent down the tower into underground storage such as caves
epleted gas wells through pipelines.
he **pressurized air can be released when needed to power an electricity generator**, ev
wind is not spinning the turbine.
lechanology", a compressor research and development firm, has designed a compressor a
s tested a prototype wind energy storage system. The company plans to build its largesc
rsion now.

wind power plant can also be integrated with pumped storage plant. The excess power generated
n be utilized to store water at a higher reservoir.
he stored energy can be later recovered by running the pumped storage plant as a normal hydro
ant.
e **excess wind energy can also be stored as thermal energy** (e.g. hot water) and may be utilized la
r space heating, heating of green house or crop drying.

Sizes and Applica

Small (≤10 kW)

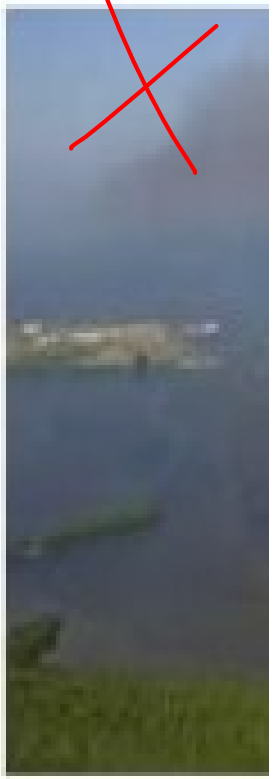
- Homes
- Farms
- Remote Application



ADVANTAGES & DISADVANTAGES

Advantages of Wind Pow

- Environmental Benefits
- Economic Development Benefits
- Fuel Diversity & Conservation Benefits
- Cost Stability Benefits



Why Wind Energ

- Wind, for now, is the renewable energy resource/
- "Free" resource
- A "clean" resource due to:
  - Replacement of a "dirty" energy source (coal) and,
  - No emissions associated with its use
- Can be utilized on underutilized land or on lands
  crop production ("harvest" on the surface and "ha
  surface)

Wind Ene

- No air em
- No fuel t
  store
- No coolin
- No water
- No waste

Advantages

- Safe, clean, renewable form of energ
- No air pollution or waste materials pr not contribute to global warming or c
- Minimal effect on local ecosystems. l farmed at the same time.
- Winds are stronger in winter when d electricity rises

Disadvantages

- Birds - A Serious Obstacle
- Noise Disturbances
- Cost of Wind Turbine
- Threat to Wildlife
- Wind Can Never Be Predicted

DISADVANTAGES OF WIND E

- Wind energ
  in nature ar
  storm force
- Wind energ
  operation; a
  many kilom
- Birds and b
  flying into t

Disadvantages

- 30m tall – visual concerns es
  grouped together on 'wind f
- Expensive to build and main
- Wind does not blot all the t
- Hum noise and can interrup

Cost Economics

Energy Cost Tre

1979: 20 INR/kWh

2000: 3 INR/kWh

- Increased

Scale of Wind Turbines

Scale	Rotor diameter
Micro	Less than 3 m
Small	3 m to 12 m

CRITERION

- Criterion for identification of a potential site

- Sites having wind power density greater than 200 W/m^2 at 50 m height

ECONOMICS

- Annual Energy Production
- Capital Cost
- Annual capital charge rate
- Pay back period
- Operation & maintenance cost, insurance, land leasing, e
- Life Cycle Cost Analysis

ANNUAL ENERGY PRODUCTION DEPENDS

- Speed power curve of wind turbine
- Wind speed frequency distribution of site
- Availability of wind turbine

Average Wind Speed i

- Most important variable

  Power ~ V^3

- Double speed and pow
  increases 8 times
- 73% more power in a 1
  wind than a 10 mph wi
- This is why it is so impor

Factors Affecting

- Elevation
- Obstructions
- Surface Roughness
- Perpendicular Ridg
- Time of day

ENVIRONMENTAL ASPECTS

ENVIRONMENTAL ASPECTS
Main environmental concerns are discussed below

direct Energy Use and Emissions

Energy is required to produce materials used to construct the wind turbine and in its installation.

rd Life

Large wind turbines pose a threat to bird life as a result of collision with tower or blades. Their resting and breeding patterns are also affected.

oise

The disturbance caused by the noise produced by wind turbine s one of the important factors that prevent its siting close to nhabited areas.

4. **Visual Impact**
   - Wind turbines are massive structures quite v over a wide area in most locations. Visual impa wind turbine is qualitative in nature.
5. **Telecommunication Interference**
   - Wind turbines present an obstacle for inc electromagnetic waves (i.e. TV or microwave sign
6. **Safety**
   - Accidents with wind turbines are rare but the happen, as in other industrial activities
7. **Effects on Ecosystem**
   - Large-scale use of wind generation can reduce speed and cause stress to ecosystem. Lakes tha downhill from the wind turbines might be warmer because of reduced evaporation from surface.

Environmental Impact

Noise

- **Mechanical Noise - gear box, generator**
- **Aerodynamic Noise - Swishing sound**
- **Wind farm at 350 m away**
- ***noise level - dB(A) 35-45***
- **Electromagnetic interference**
- **Visual impact**
- **Shadow flicker**
- **Ecology, Loss of Bird Life**

Thank You

Save energy and water for Sustainable Life

ENSAVE ACADEMY

Dr.P.Dharmalingam
Accredited Energy Auditor
Director, EnSave Academy
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