

EXTRA HIGH  
VOLTAGE  
(EHV) AC  
TRANSMISSION

# INTRODUCTION

The term high voltage characterizes electrical circuits in which the voltage used is the cause of particular safety concerns and insulation requirements. High voltage is used in electrical power distribution, in cathode ray tubes, to generate X-rays and particle beams, to demonstrate arcing, for ignition, in photomultiplier tubes, and high power amplifier vacuum tubes and other industrial and scientific applications.

## ❖ **WHAT IS EHV TRANSMISSION ?**

Two factors considered in the classification of a "high voltage" are the possibility of causing a spark in air, and the danger of electric shock by contact or proximity.

❑ In electric power transmission engineering, high voltage is usually considered any voltage over approximately 35,000 volts.

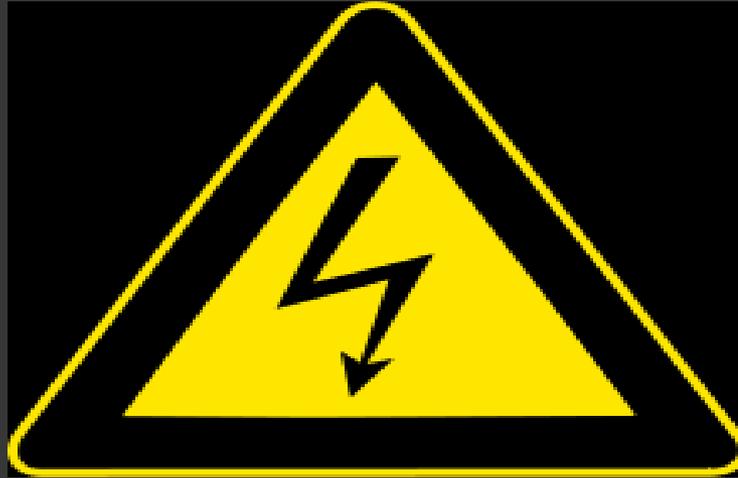
❑ In digital electronics, a high voltage is the one that represents a logic 1; this may be only several hundred millivolts for some logic families.

❑ In electric power transmission engineering this refers to equipment designed for more than 345,000 volts between conductors. In electronics systems, a power supply that provides greater than 275,000 volts is known as an "EHV Power Supply". It is often used in experiments in physics.

### SAFETY:

❑ Voltages of greater than 50 V applied across dry unbroken human skin are capable of producing heart fibrillation if they produce electric currents in body tissues which happen to pass through the chest area.

❑ The electrocution danger is mostly determined by the low electrical conductivity of dry human skin.



(International safety symbol "Caution, risk of electric shock" (ISO 3864), colloquially known as high voltage symbol)

- ❑ Accidental contact with high voltage supplying sufficient energy will usually result in severe injury or death.
- ❑ Low-energy exposure to high voltage may be harmless, such as the spark produced in a dry climate when touching a doorknob after walking across a carpeted floor.

# POWER LINES

Electrical transmission and distribution lines for electric power always use voltages significantly higher than 50 volts, so contact with or close approach to the line conductors presents a danger of electrocution.



(High tension power lines)

For high voltage and extra-high voltage transmission lines, specially trained personnel use so-called "live line" techniques to allow hands-on contact with energized equipment.

# NECESSITY FOR EHV TRANSMISSION

- ❑ With the increase in transmission voltage, for same amount of power to be transmitted current in the line decreases which reduces  $I^2R$  losses. This will lead to increase in transmission efficiency.
- ❑ With decrease in transmission current, size of conductor required reduces which decreases the volume of conductor.
- ❑ The transmission capacity is proportional to square of operating voltages. Thus the transmission capacity of line increases with increase in voltage.
- ❑ With increase in level of transmission voltage, the installation cost of the transmission line per km decreases.
- ❑ It is economical with EHV transmission to interconnect the power systems on a large scale.
- ❑ The no. of circuits and the land requirement for transmission decreases with the use of higher transmission voltages.

# ADVANTAGES OF EHV TRANSMISSION

The major advantages are:

- ❑ Reduction in the current.
- ❑ Reduction in the losses.
- ❑ Reduction in volume of conductor material required.
- ❑ Decrease in voltage drop & improvement of voltage regulation.
- ❑ Increase in Transmission Efficiency.
- ❑ Increased power handling capacity.
- ❑ The no. of circuits & the land requirement reduces as transmission voltage increases.
- ❑ The total line cost per MW per km decreases considerably with the increase in line voltage.

# DISADVANTAGES OF EHV TRANSMISSION

The major disadvantages are:

- ❑ Corona loss & radio interference
- ❑ Line supports
- ❑ Erection difficulties
- ❑ Insulation needs
- ❑ The cost of transformers, switchgear equipments & protective equipments increases with increase in transmission line voltage.
- ❑ The EHV lines generates electrostatic effects which are harmful to human beings & animals.

# TECHNOLOGY IN EHV AC TRANSMISSION

FACTS technologies have a small footprint and minimal impact on the environment. Project implementation times are considerably faster and investment costs substantially lower than the alternative of building more transmission lines or new power generation facilities.

FACTS consists of three technology branches:

- series compensation
- dynamic shunt compensation
- dynamic energy storage

## Series compensation:

Series compensation was invented by ABB in 1950. It made possible the world's first 400 kV transmission in the 1950s by resolving the issue of how to transmit power over long distances.



(SC in Imperatriz, Brazil)

The benefits of series compensation - improved system stability, increased transmission capacity, and reduced overall power losses.



(SVC in Newark, US)

- ❑ As transmission capacities rose, so did the need for higher series compensation voltages.
- ❑ Controllable series compensation (TCSC) was installed by ABB in the late 1990s and is also part of the FACTS family.

## SVC Light®:



(SVC Light)

In 1998, ABB launched a new generation of dynamic shunt compensation technology for transmission, steel and rail applications - SVC Light (often referred to in the United States by the generic name STATCOM).

## SVC Light with Energy Storage:

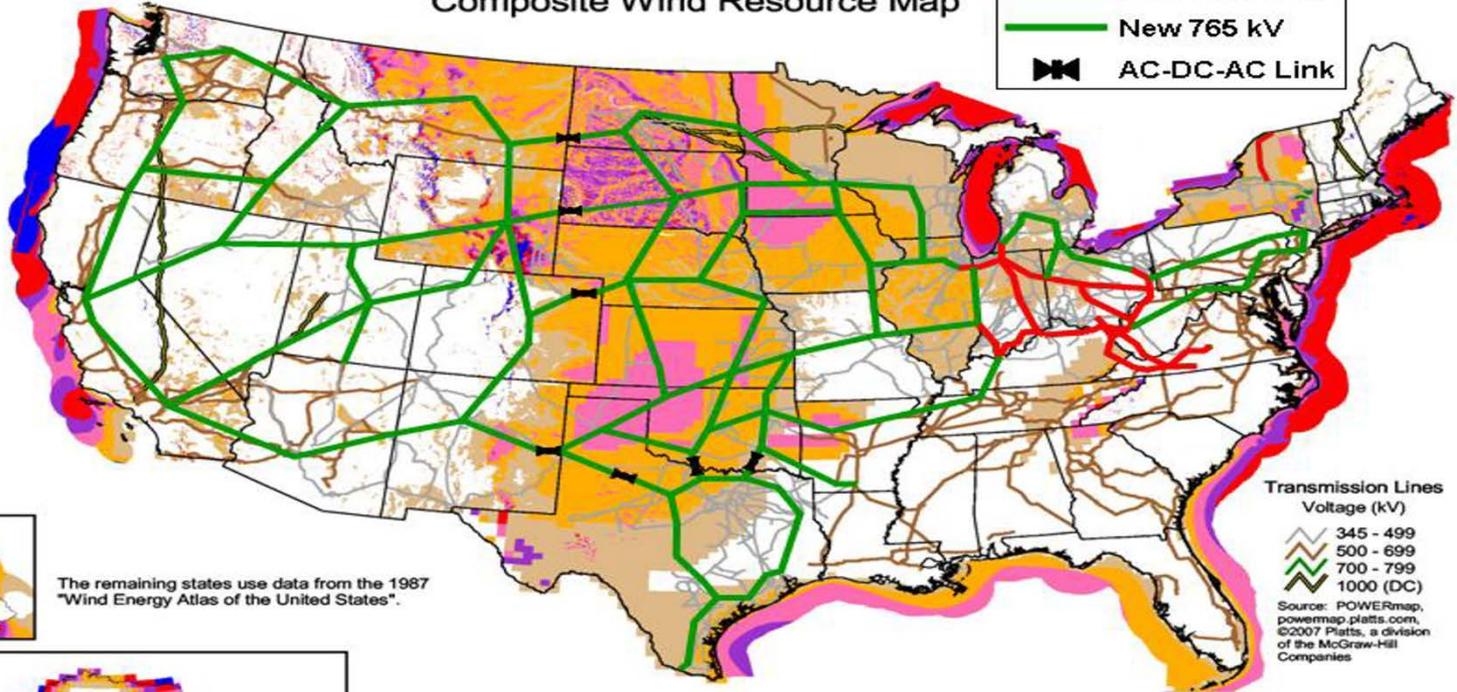
- ❑ The integration of dynamic energy storage into transmission and distribution systems has the potential.
- ❑ The new technology is based on SVC Light, combined with Li-ion battery storage.

# FUTURE OF EHV AC TRANSMISSION

- Updated Maps:
- Arizona (2003)
  - California (2002)
  - Colorado (2004)
  - Connecticut (2001)
  - Delaware (2002)
  - Hawaii (2004)
  - Idaho (2002)
  - Illinois (2001)
  - Indiana (2004)
  - Maine (2001)
  - Maryland (2002)
  - Massachusetts (2001)
  - Michigan (2004)
  - Missouri (2005)
  - Montana (2002)
  - Nebraska (2005)
  - Nevada (2003)
  - New Jersey (2002)
  - New Hampshire (2001)
  - New Mexico (2003)
  - North Carolina (2002)
  - North Dakota (2000)
  - Ohio (2004)
  - Oregon (2002)
  - Pennsylvania (2002)
  - Rhode Island (2001)
  - South Dakota (2001)
  - Texas (2000)
  - Utah (2003)
  - Vermont (2001)
  - Virginia (2002)
  - Washington (2002)
  - West Virginia (2002)
  - Wyoming (2002)

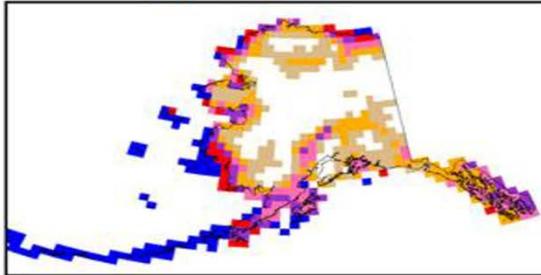
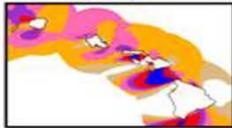
Composite Wind Resource Map

- Existing 765 kV
- New 765 kV
- AC-DC-AC Link



- Transmission Lines  
Voltage (kV)
- 345 - 499
  - 500 - 699
  - 700 - 799
  - 1000 (DC)
- Source: POWERmap, powermap.platts.com, ©2007 Platts, a division of the McGraw-Hill Companies

The remaining states use data from the 1987 "Wind Energy Atlas of the United States".



Wind Power Classification				
Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m <sup>2</sup>	Wind Speed at 50 m m/s	Wind Speed at 50 m mph
2	Marginal	200 - 300	5.6 - 6.4	12.5 - 14.3
3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	800 - 1600	8.8 - 11.1	19.7 - 24.8

<sup>a</sup> Wind speeds are based on a Weibull k value of 2.0

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National Renewable Energy Laboratory



19-APR-2007 1.5

[Conceptual Map of Interstate Grid for Wind Integration (Source: NREL)]

❑ Support is growing for a national EHV interstate transmission grid . Above figure illustrates one often referenced concept for such an interstate system, superimposed on a map of the existing EHV transmission system and wind resources in the US.

❑ The above figure indicates an overlay of predominantly 765 kV lines. Other voltages can be chosen and applied.

❑ For UHV, fewer lines would be needed, and for voltages below 765 kV more lines would be needed.

❑ It is understood, however, that the completion of this grid requires collaboration among stakeholders, especially transmission owners and operators.

# APPLICATIONS OF EHV AC TRANSMISSION

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- ❑ in photomultiplier tubes, and high power amplifier vacuum tubes and other industrial and scientific applications.

**THANK  
YOU**

# References

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