

05-Power Systems Basics

ECEGR 452

Renewable Energy Systems



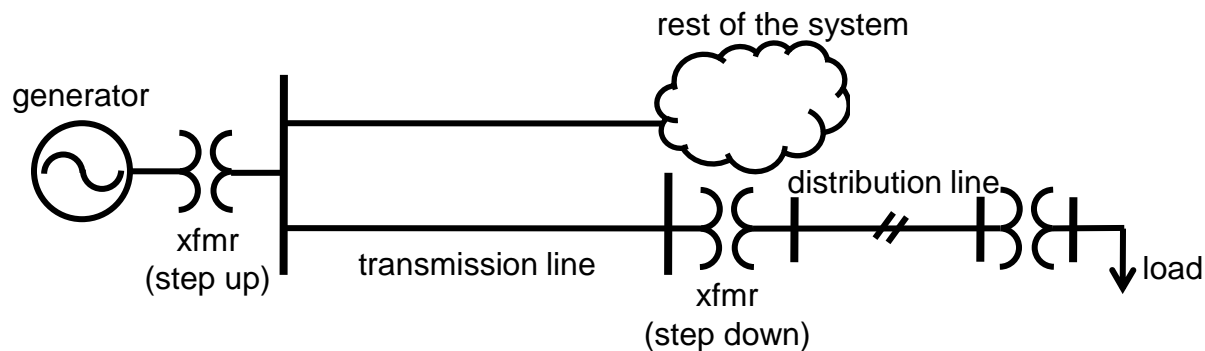
Overview

- Transmission
- Three Phase Analysis
- Transformers



Introduction

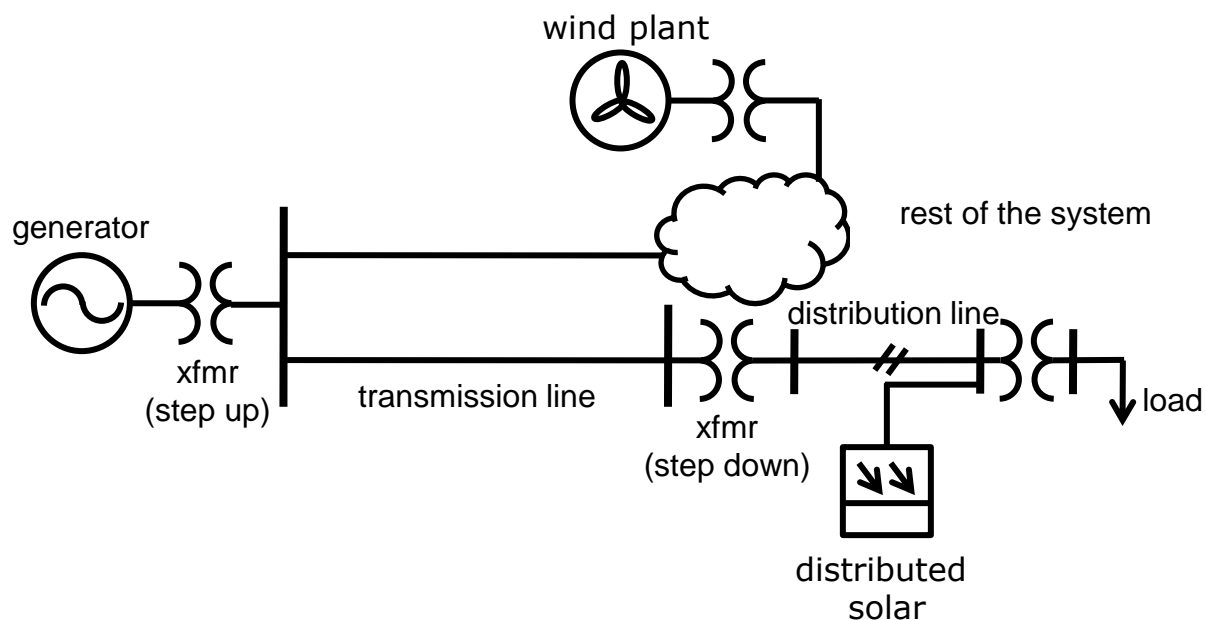
- Power systems can be divided into three subsystems
 - generation
 - transmission
 - load
- Transmission is often separated into transmission and distribution





Introduction

Renewable energy is integrated into the existing (legacy) power system



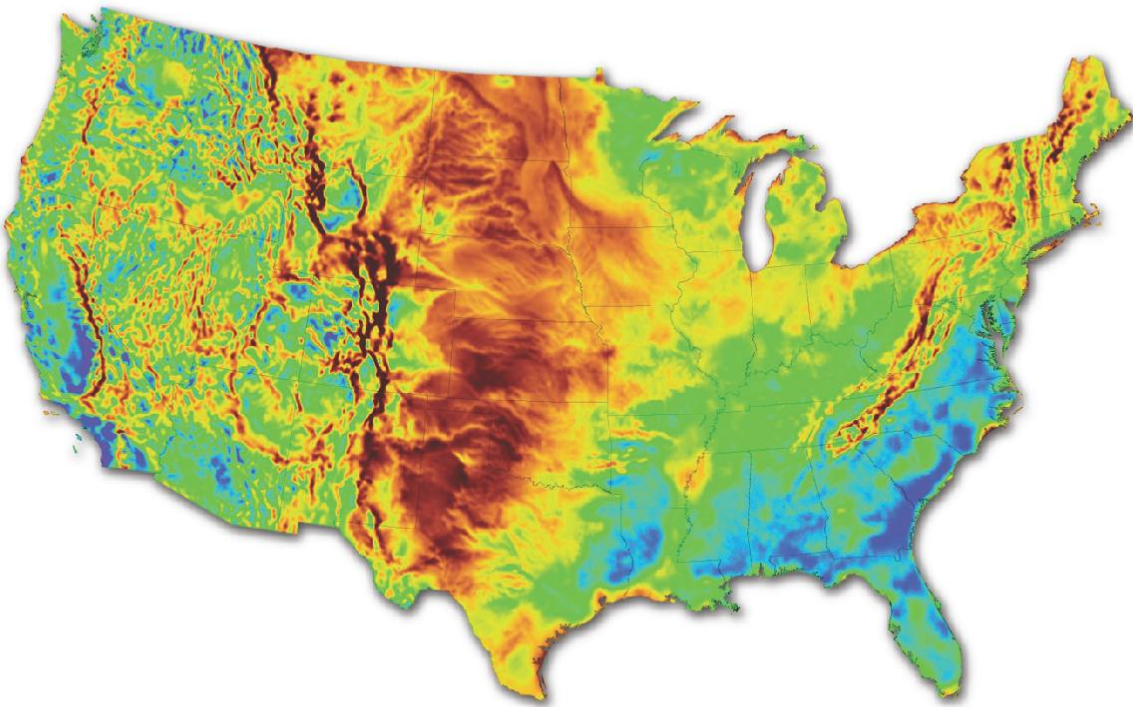


Introduction

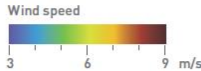
- Areas with abundant renewable resources do not usually coincide with load centers
- Access to transmission is and will continue to be a major challenge for the growth of renewable energy

Wind Resources

U.S. Wind Map at 80m



5km Wind Map at 80m



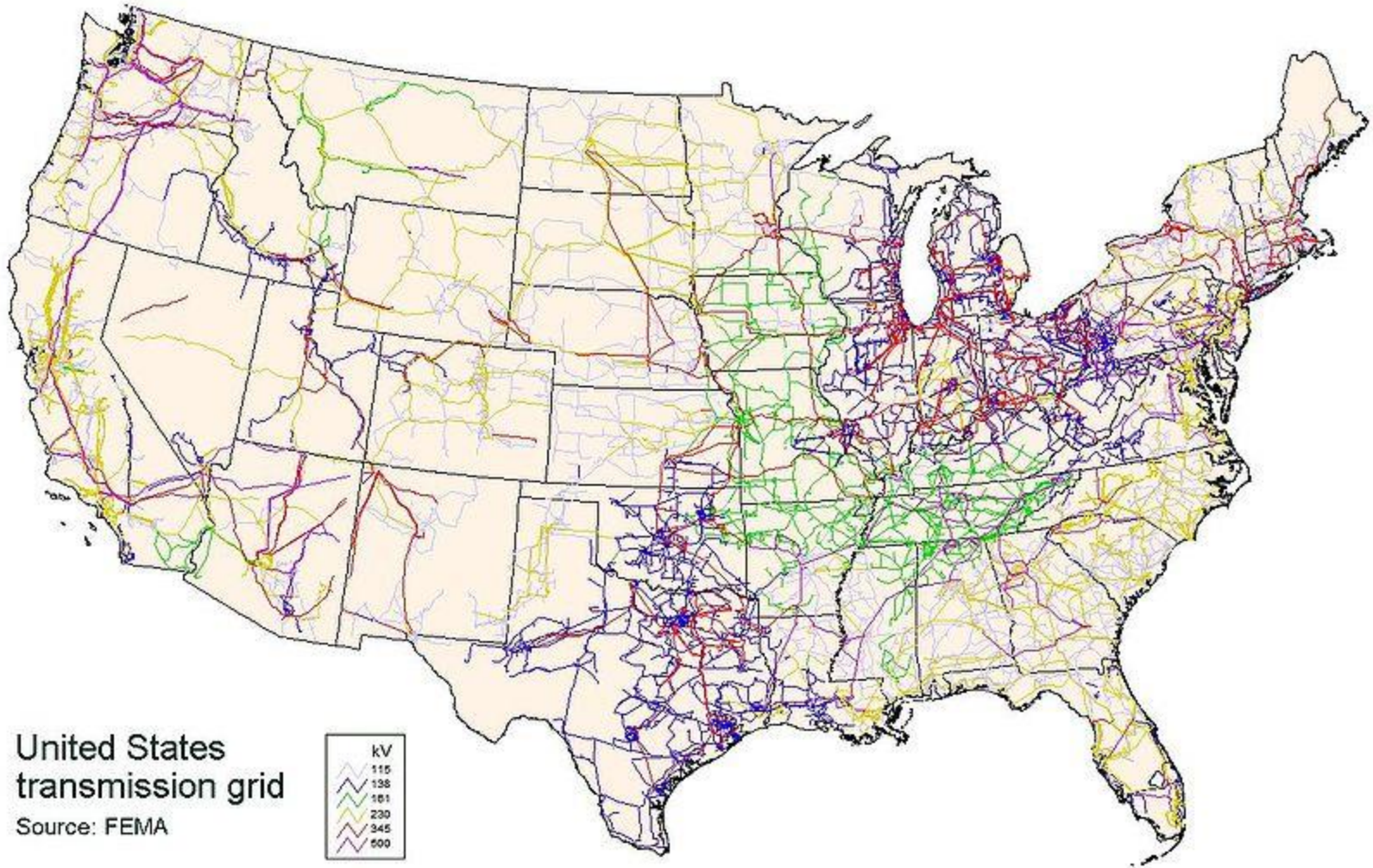
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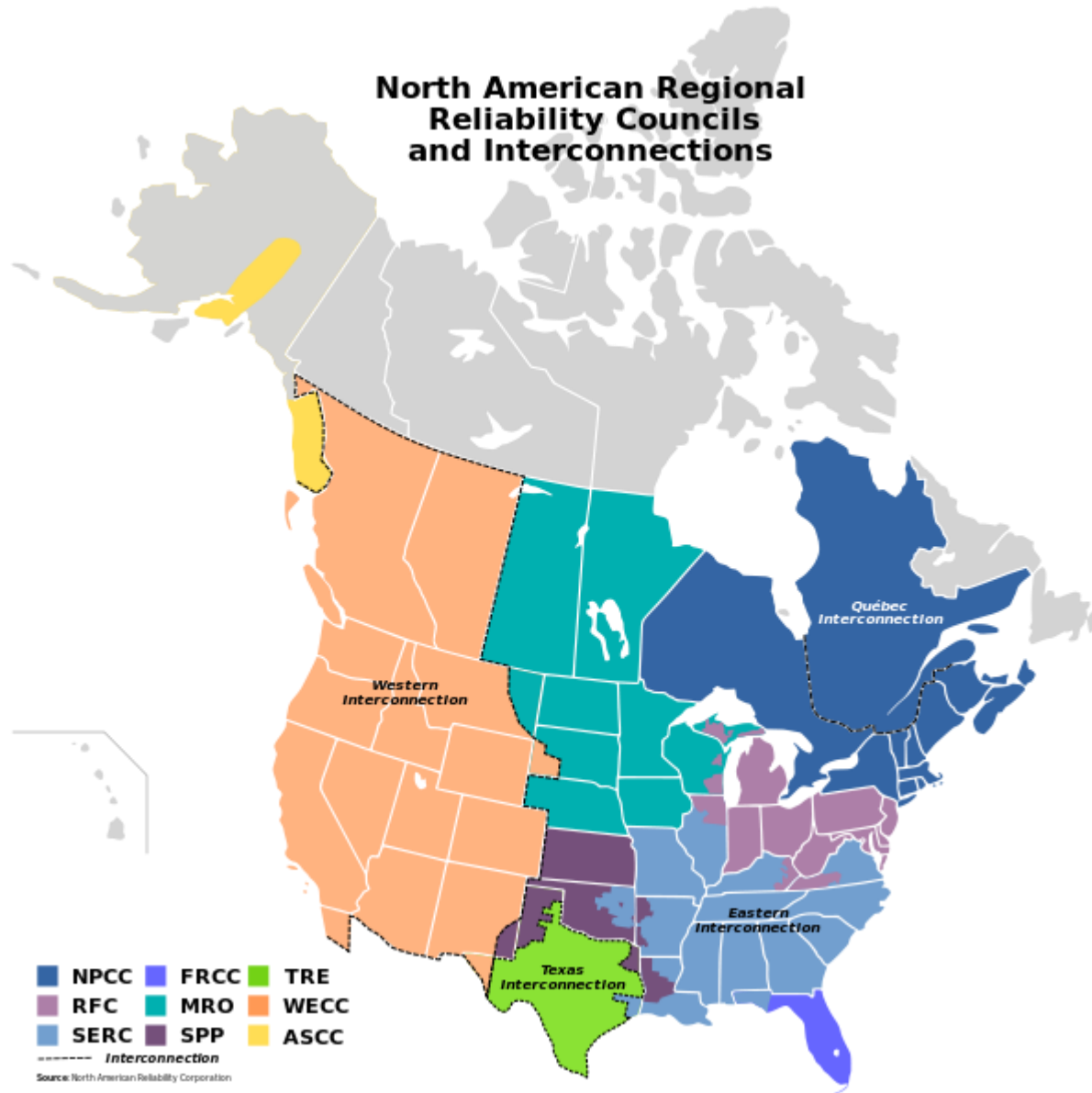
Load



Transmission



North American Regional Reliability Councils and Interconnections





Transmission

- Provide low impedance path from generators to load serving entities





Transmission Challenges

- Capital cost
- Economic risk
- Environmental
 - right-of-way
 - visual
 - audio
 - health?
- Social resistance
 - (NIMBY)



Transmission Costs (example)

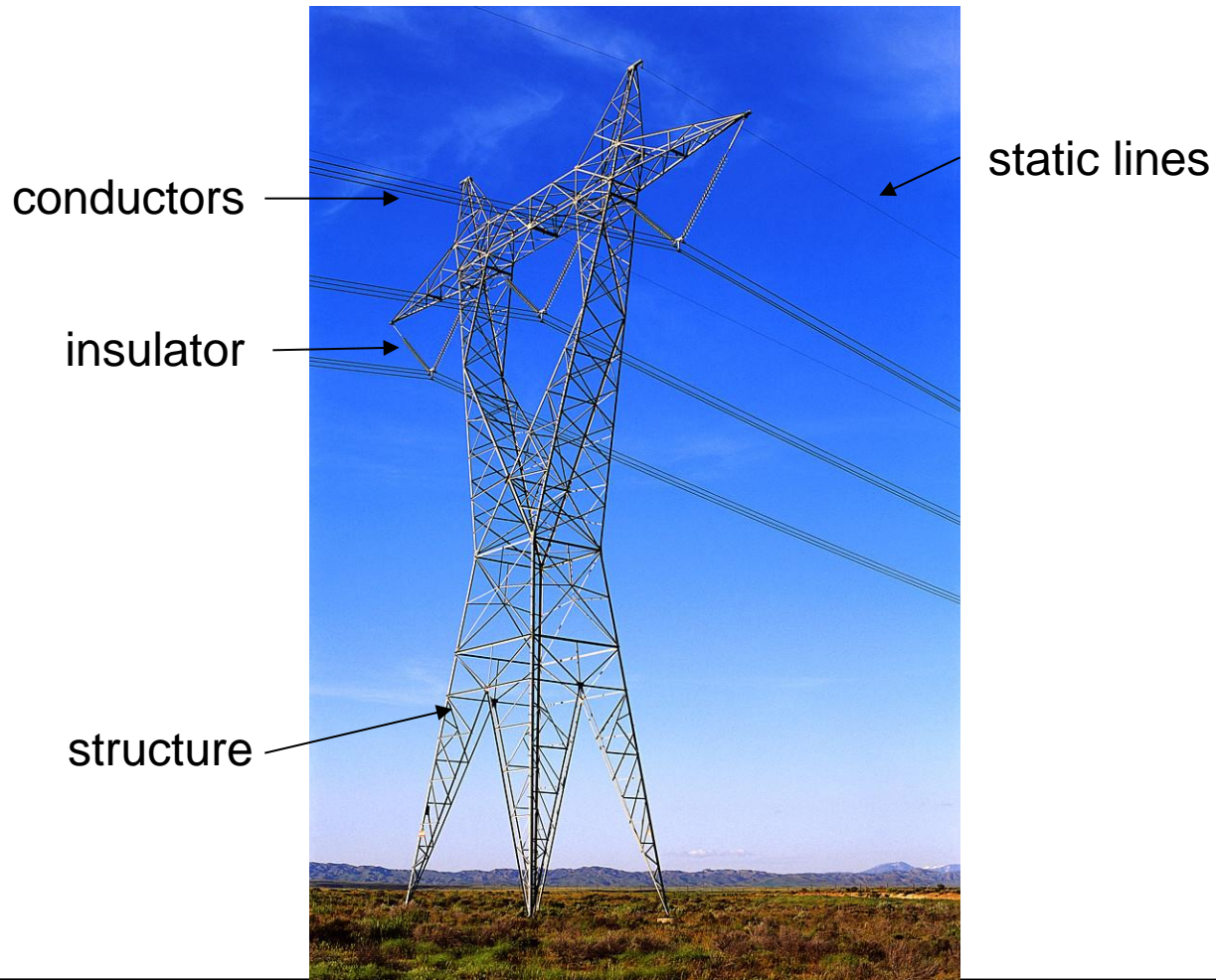
- Example Base costs:
 - 115kV: \$1,350,000/mile
 - 230 kV: \$1,600,000/mile

Source: CAISO

- Example Multipliers
 - Hilly (x1.2)
 - Forested (x1.5)
 - Urban (x1.5)



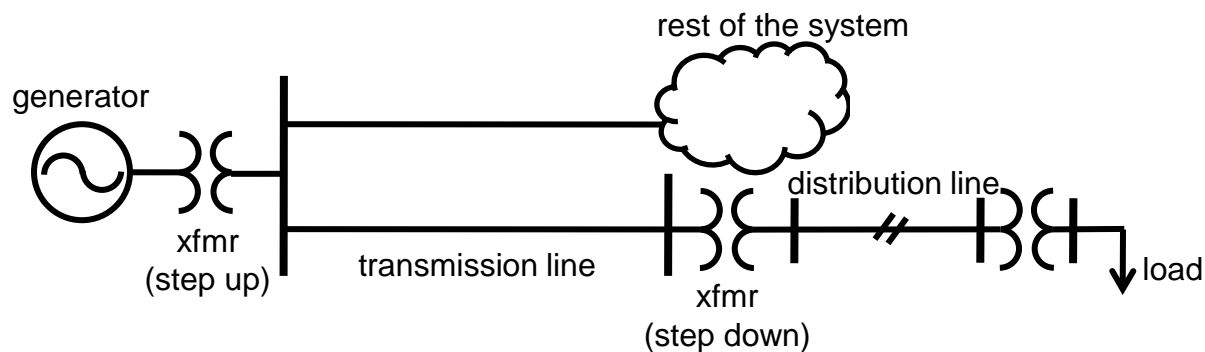
Transmission Line Anatomy





Transformers

- Generate power at a voltage suitable for energy conversion
- Step-up voltage for efficient transmission
- Step down voltage for consumption at safe levels









Transformers

- Shifting between voltage levels
 - generation 11 to 30 kV
 - transmission up to 765 kV
 - distribution around 69 kV
 - residential 240/120 V
- Controlling voltages, power flows
 - regulating transformers



Further Details

- Further details are covered in the electives
 - ECEGR 450: Electromechanical Energy Conversion
 - ECEGR 451: Power Systems Analysis
 - ECEGR 457: Electromechanical Conversion Laboratory