RENEWABLE ENERGY SYSTEMS

ELECTRICAL ENERGY STORAGE (EES)

Prof. Ibrahim El-mohr
Prof. Ahmed Anas

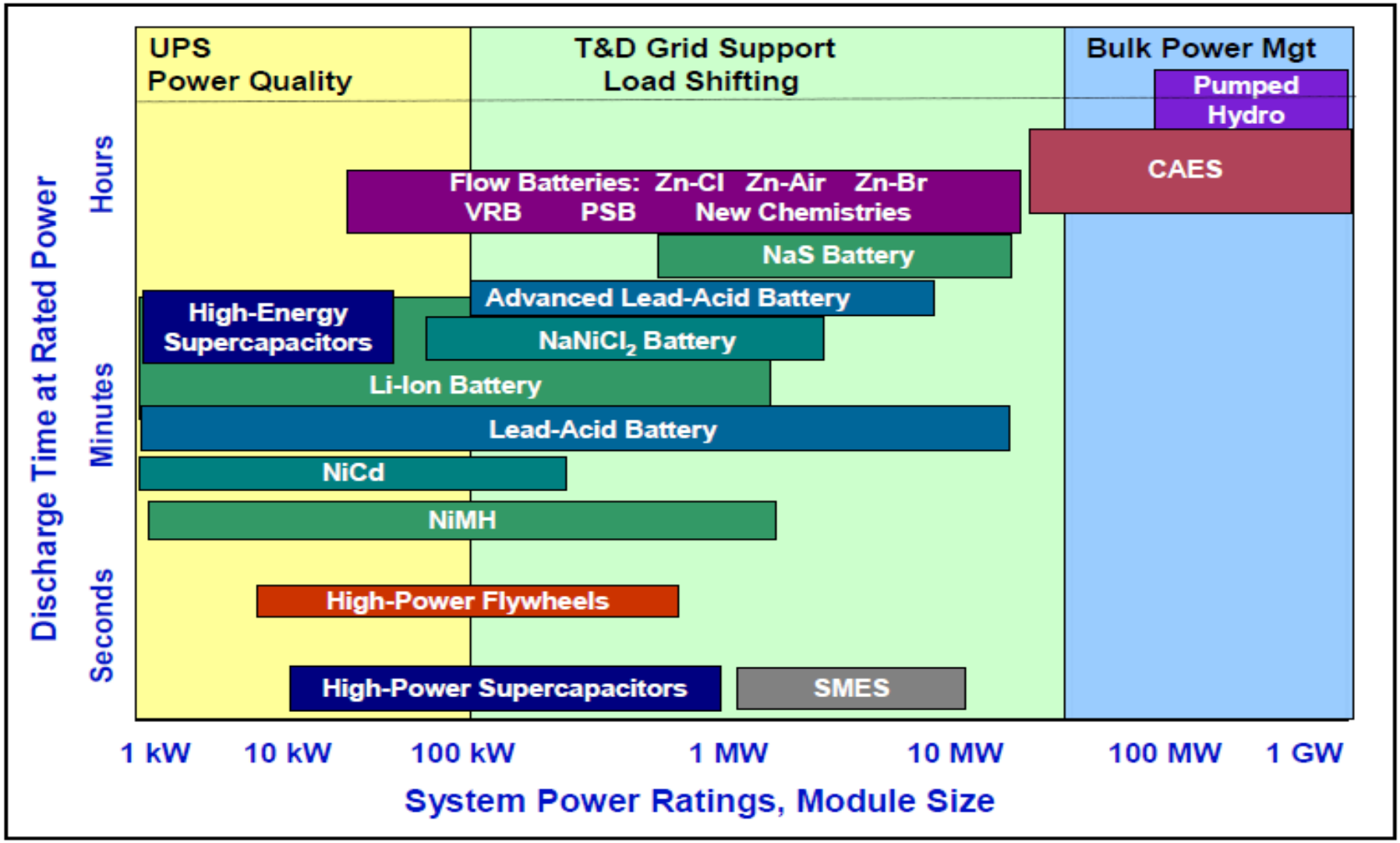
Outline

- Introduction
- Energy Storage for Mitigating the Variability of Renewable Electricity Sources
- Energy Storage Technologies
  - Pumped Hydro Storage
  - Compressed to Air Energy Storage
  - Batteries
  - Superconducting Magnetic Energy Storage
  - Hydrogen Storage
  - Flywheels
  - Capacitors and Super-capacitors

Introduction

- Electrical Energy Storage (EES) refers to a process of converting electrical energy from a power network into a form that can be stored for converting back to electrical energy when needed.
- Such a process enables electricity to be produced at times of either low demand, low generation cost or from intermittent energy sources and to be used at times of high demand, high generation cost or when no other generation is available.
- The installed EES capacity is approximately 125 GW worldwide, mostly from pumped hydro. This capacity is about 3% of the world's total generation capacity of 3,900 GW.

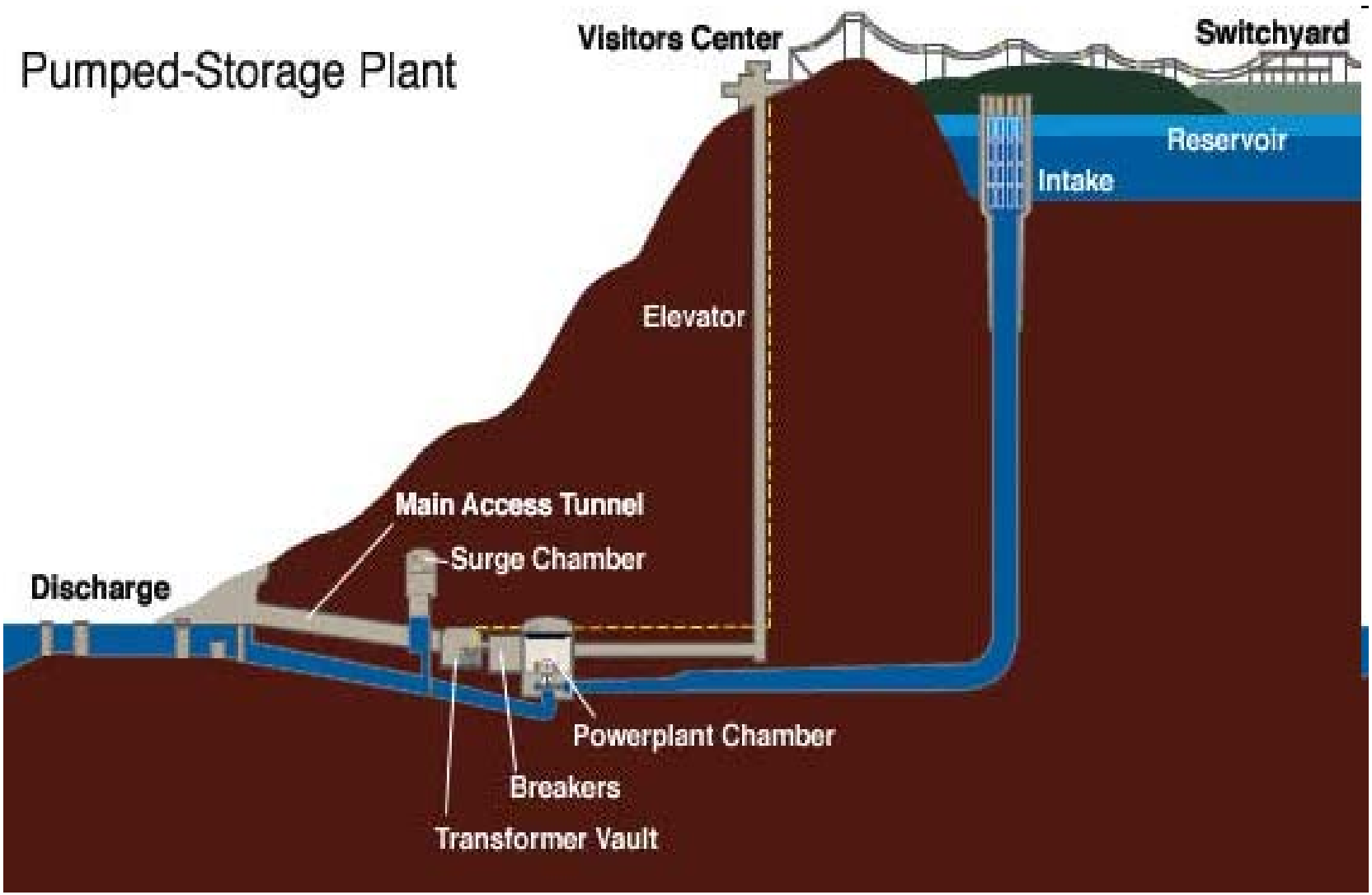
Energy Storage Technologies



Pumped Hydro Storage

- Pumped hydroelectric storage (PHS) stores potential energy from height differences in water levels, and differs from ordinary hydroelectric power because it has the ability to pump water from the lower reservoir to the upper reservoir.
- It is the most common form of energy storage, representing approximately 97% of the total storage capacity.
- The reason that PHS has been very popular as an energy-storage medium is because it can provide relatively high efficiency (65-85%), large power capacity (typically 100-1000 MW), large storage capacity (1-24+ hours), and a long life (30-60 years), at a low cycle cost (0.1-1.4 $/kWh/cycle)

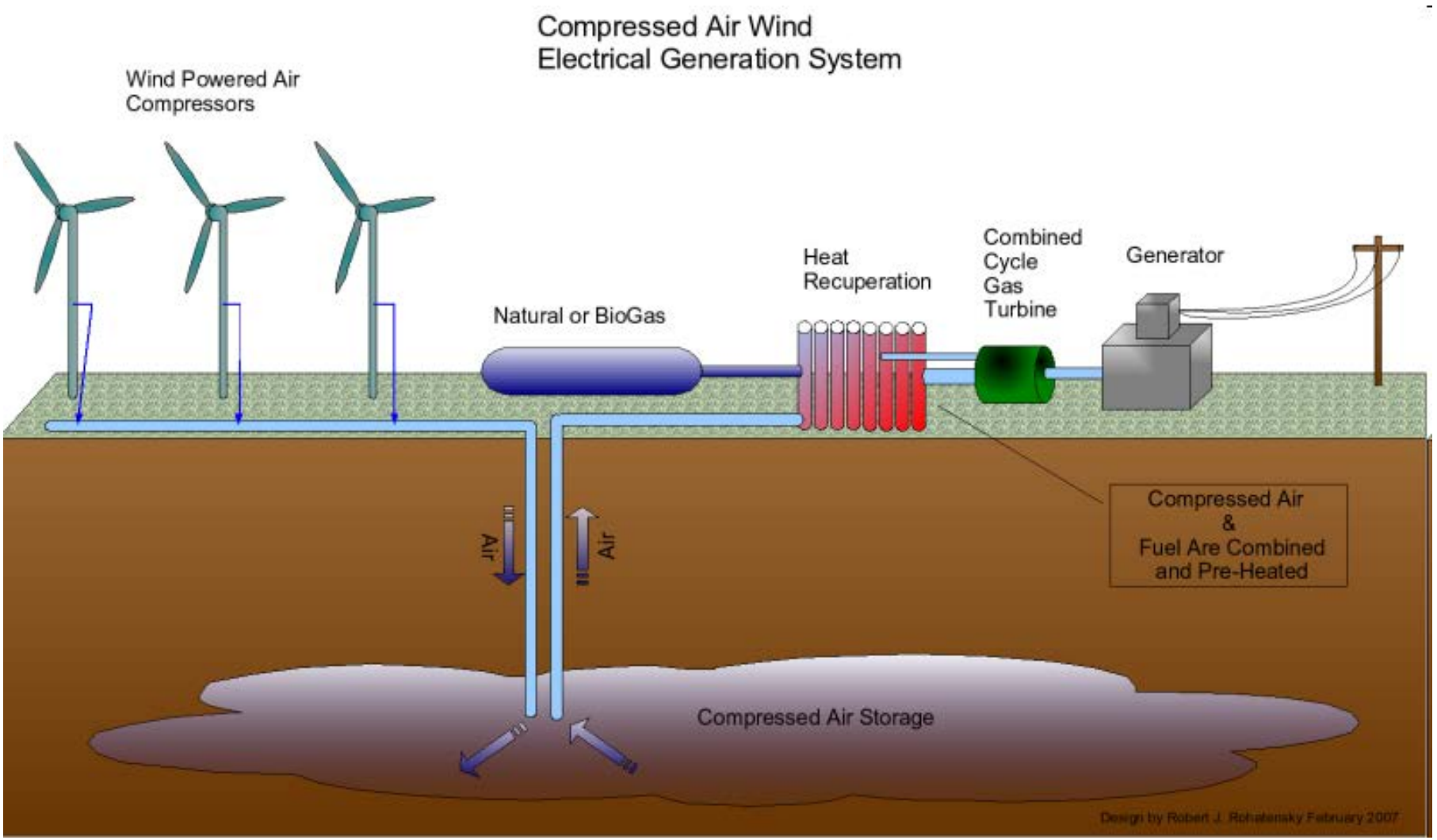
Pumped Hydro Storage



Compressed Air Energy Storage

- Compressed Air Energy Storage CAES is a technology in which energy is stored in the form of compressed air in an underground cavern. Then, during periods of peak demand, the air is used to generate power with a turbo-generator system.
- A typical CAES system uses an existing underground site (e.g., a salt dome, a rock cavern, or an abandoned mine), and stores gas at approximately 4 to 8 mega-pascals.
- CAES and PHS are the only storage technologies that are currently suitable for large-scale power and high energy-storage applications. Research shows that CAES is a viable method to mitigate wind variability for wind leveling and energy management purposes.

CAES with wind energy system



Superconducting Magnetic Energy Storage

- A super conducting magnetic energy-storage (SMES) unit is a device that stores energy in the magnetic field generated by direct current flowing through a superconducting coil.
- SMES is a relatively new technology with low exposure to power applications, although one estimate reports that there may be as much as 100 MW capacity already installed in the world .
- SMES units can only generate electricity at rated capacity for a few seconds, have strong magnetic fields, and are extremely expensive at 1,000 to 10,000$/kW.

Superconducting Magnetic Energy Storage

- Micro-SMES devices in the range of 1 to 10 MW are commercially available, and over 30 devices with approximately 50 MW of total capacity are installed in different parts of the United States for good power quality or uninterruptible power supply.

Hydrogen Storage

- Hydrogen differs from the conventional idea of energy storage because it uses separate processes for hydrogen production, storage, and use.
- For hydrogen production, an electrolyzer produces hydrogen and oxygen from water by introducing an electric current. A hydrogen fuel cell converts hydrogen and oxygen back into water to release energy.
- Different strategies of integrating wind and solar energy with hydrogen storage are under research.


Thanks

Any Questions...
Just Ask!