Energy Storage

A. Introduction

ENERGY STORAGE WILL BECOME MORE OF A FOCUS AS THE AMOUNT OF RENEWABLE ENERGY PROVIDING ELECTRICITY INCREASES

- VARIABLE ENERGY PRODUCTION
- DETAILS OF VARIATION ARE COMPLICATED

ENERGY STORAGE REDUCE THE REQUIRED INSTALLED CAPACITY FOR ALL SOURCES

SOME SOURCES OF ENERGY HAVE BUILT IN STORAGE

- HYDROELECTRIC
- FOSSIL FUELS
- BIOMASS
- GEOTHERMAL

OTHERS DO NOT

- WIND ENERGY
- TIDAL ENERGY
- SOLAR ENERGY
- WAVE ENERGY

Energy Storage

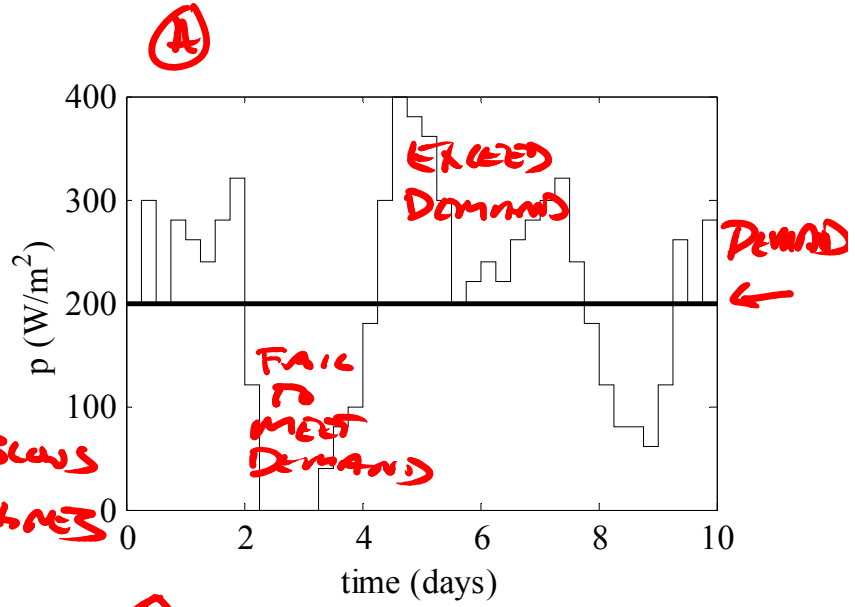
A. Introduction

   1. Renewable Energy Sources without Storage

ENERGY SOURCES W/O STORAGE CAN NOT PRODUCE ON DEMAND

→ WIND ENERGY WHEN WIND BLOWS

→ SOLAR ENERGY WHEN SUN SHINES

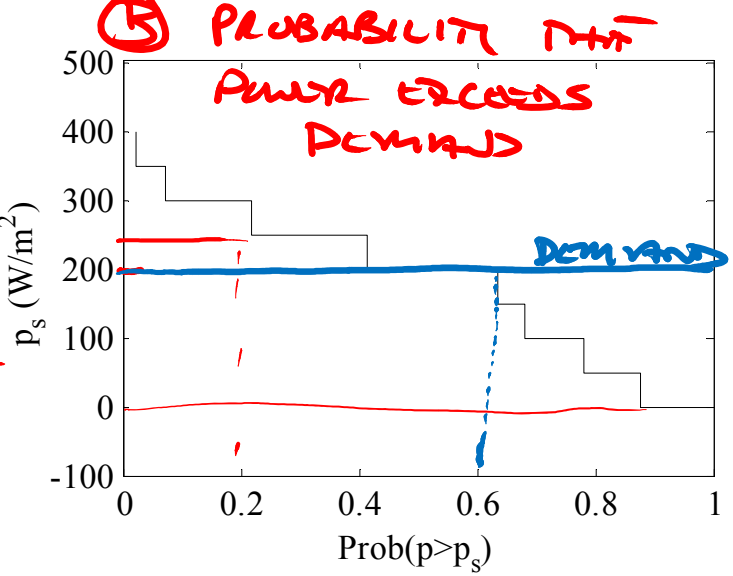


CONSIDER WIND ON AN ISOLATED GRID

Ⓐ POWER PRODUCTION AS A FUNCTION OF TIME

Ⓑ PROBABILITY THAT POWER EXCEEDS A THRESHOLD

~40% OF TIME, DEMAND NOT MET



Energy Storage

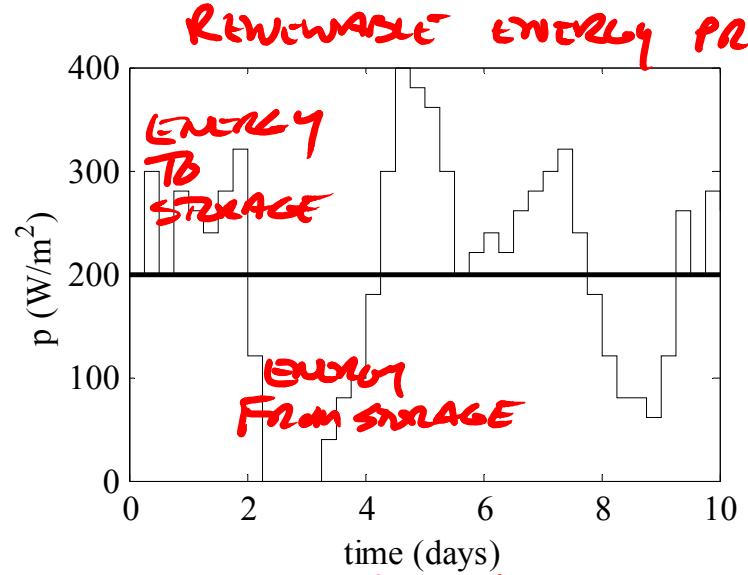
A. Introduction

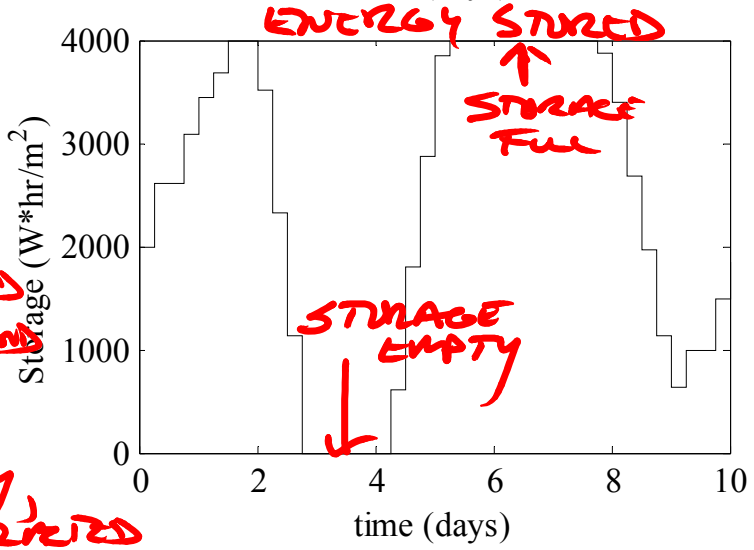
   2. Renewable Energy Sources with Storage

ADDING STORAGE TO THE SYSTEM CHANGES IB CHARACTERISTICS

STORAGE WORKS AS FOLLOWS

- POWER GENERATION EXCEEDS DEMAND
  → ENERGY FLOWS TO STORAGE
  → IF STORAGE IS FULL, NO MORE CAN BE STORED
- POWER GENERATION BELOW DEMAND
  → ENERGY FLOWS FROM STORAGE
  → IF STORAGE IS EMPTY, NO MORE CAN BE EXTRACTED





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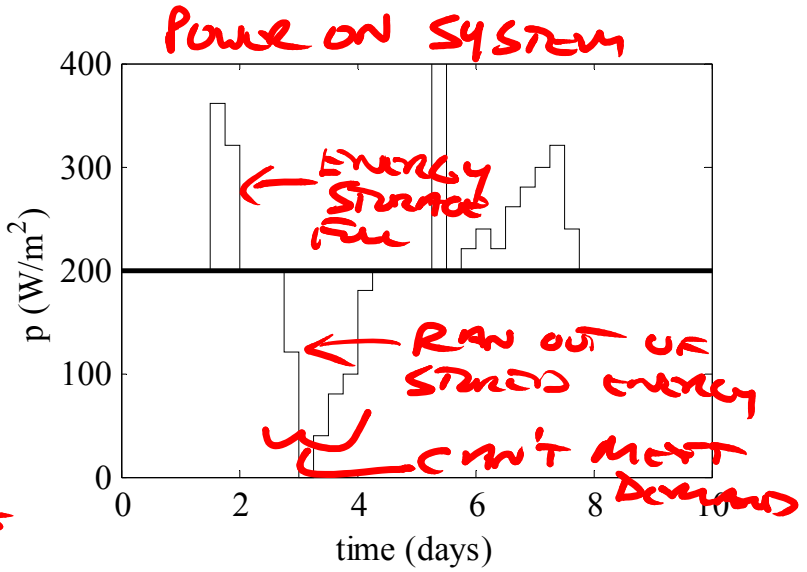
   2. Renewable Energy Sources with Storage



WHAT HAPPENS?

- ENERGY PRODUCED WHEN DEMAND LESS THAN PRODUCTION IS SAVED
- AMOUNT OF TIME LOAD CAN'T BE MET IS REDUCED
  ONLY 15 % OF TIME

EVEN BETTER RESULTS COULD BE ACHIEVED WITH LARGER STORAGE OR MORE GENERATION

EFFECTIVENESS OF STORAGE DEPENDS ON
- → ABILITY TO RECHARGE RAPIDLY
- → ABILITY TO SUPPLY POWER RAPIDLY
- → SIZE
- → ENERGY CONVERSION EFFICIENCY