PSERC

# Voltage Collapse Animation (AC)

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# Introduction

The following slides simulate a voltage collapse in a simple power system. The West generator has unlimited VAR (or reactive power) supply capability so it is able to keep the voltage at its bus constant at 1.0 per unit (or at the rated voltage). The East generator can only supply up to 1,200 MVARs (or 1,200 million VARs). There are 6,000 MWs of real power load and 1,000 MVARs of reactive power load at each bus. The West generator is transferring 3,000 MW to the East to help serve the 6,000 MW load in the East. Therefore, the outputs of the West and East generators are 9,000 MW and 3,000 MW respectively.

Six identical lines are initially in service and the 3,000 MWs of real power transfer are divided equally across the lines. The generators in the West and East are supplying reactive power (or VARs) to their local loads plus VARs to the transmission lines to support the transfer. The lines are assumed to be lossless (that is, they do not absorb real power). We have assumed that the individual line capacities (or thermal ratings) exceed 3,000 MW so the real power transfer could occur on one line if maintaining voltage (through sufficient VAR supply) is not a problem. Circuit breakers can open (or trip) the lines.

# Symbols in the Simulation Window

- Buses: heavy dark lines (East and West) where the generators, loads and transmission lines interconnect
- Transmission lines: lines connecting the two buses
- Generators: circles with “dog bone rotors”
- Loads: arrows connected to the buses
- Circuit breakers: red boxes
- Line flows: arrows on the transmission lines (more easily seen in the last three simulations that follow) indicate the direction and magnitude of power flow

## Simulating an AC System Voltage Collapse

Suppose the lines fail (that is, trip out) one at a time for any reason.

Case 1: No Lines Out. Bus voltages at 1.0 per unit (or rated voltage). Both bus voltages are being controlled by their respective generator VAR supplies.

Case 2: One Line Out. Bus voltages at 1.0 per unit (or rated voltage). Both bus voltages are being controlled by their respective generator VAR supplies.

Case 3: Two Lines Out. Bus voltages at 1.0 per unit (or rated voltage). Both bus voltages are being controlled by their respective generator VAR supplies although the East generator has just hit its VAR limit.

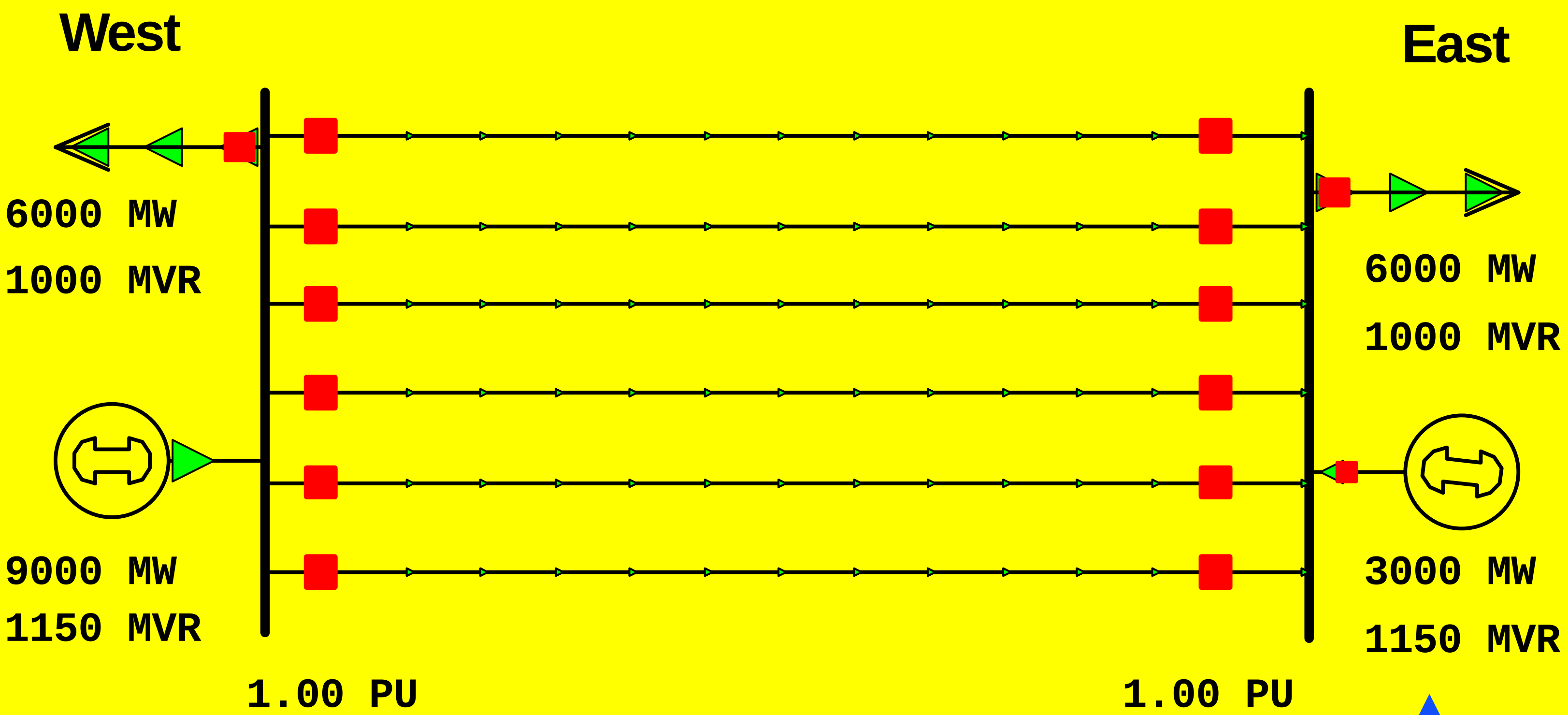
Case 4: Three Lines Out. East bus voltage at 0.99 per unit because East generation is at its reactive power supply limit. West generation still has unlimited reactive power supply capability.

Case 5: Four Lines Out. East bus voltage drops to 0.97 per unit. East generation at its reactive power supply limit. West reactive power generation continuing to rise.

Case 6: Voltage collapse! With five lines out, the simulation fails – which indicates that it is not possible to transfer 3,000 MW without additional reactive power support in the East even if West generation has excess reactive power supply capacity!

# Case 1: All Lines In-Service

## 3,000 MW transfer – 500 MW per line




**Voltage is 100% of rated voltage. (300 MVARs required by lines).**

**East generator is below 1,200 MVAR limit.**

# Case 2: One Line Out

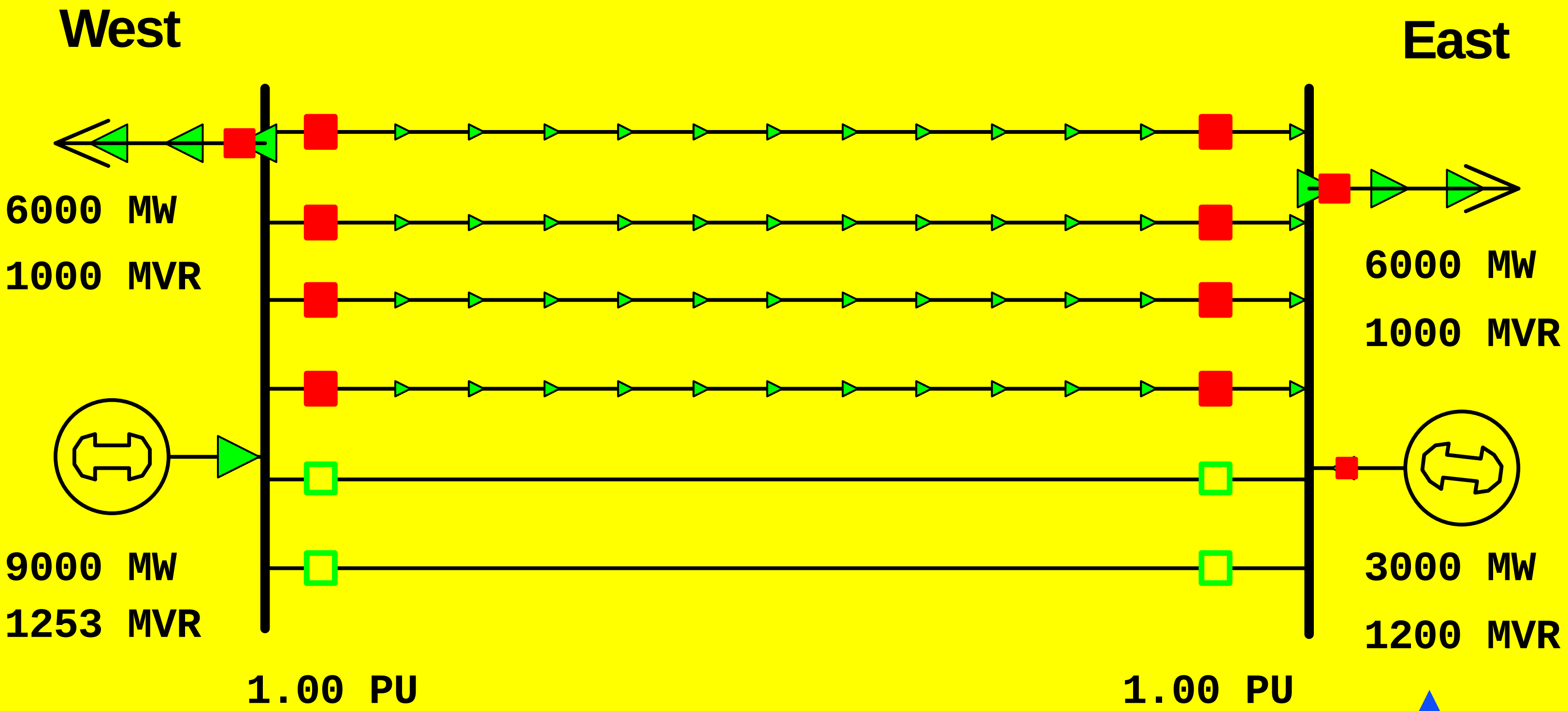
## 3,000 MW transfer – 600 MW per line


Voltage is 100% of rated voltage (362 MVARs required by lines).

East generator is below 1,200 MVAR limit.

# Case 3: Two Lines Out

## 3,000 MW transfer – 750 MW per line

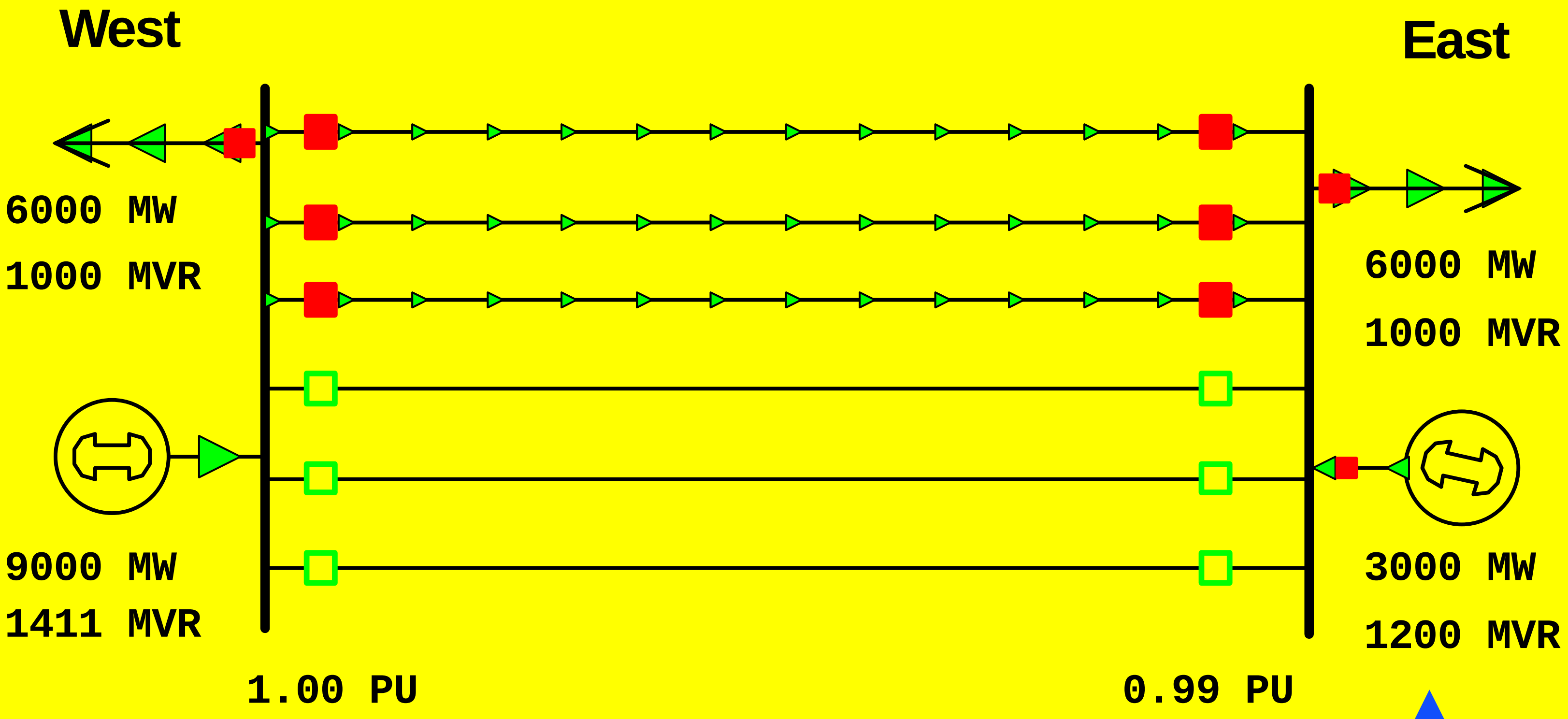



Voltage is 100% of rated (453 MVARs required by lines).

East generator is at 1,200 MVAR limit.

# Case 4: Three Lines Out

## 3,000 MW transfer – 1,000 MW per line

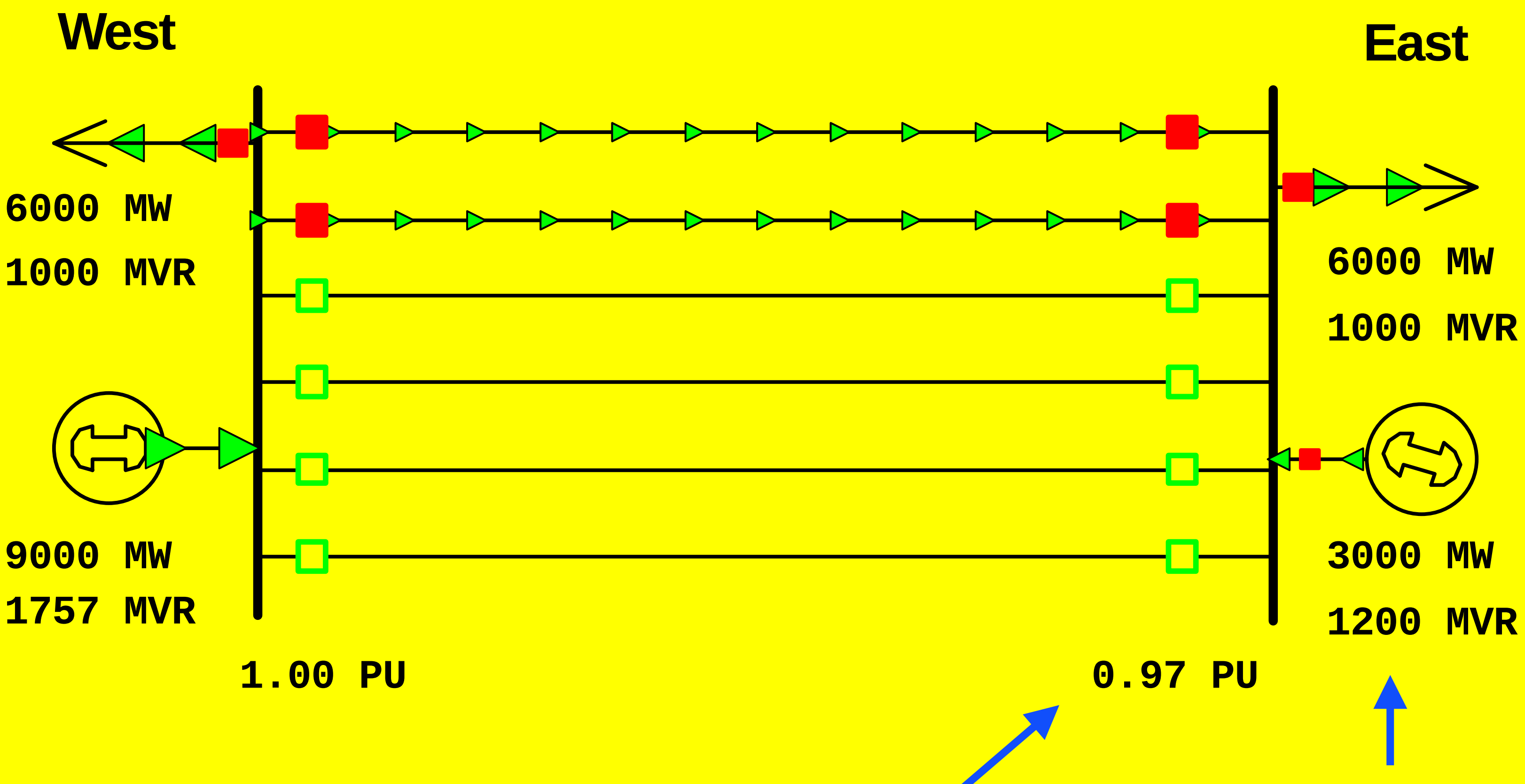



Voltage is only 99% of rated (611 MVARs required by lines).

East generator is at 1,200 MVAR limit.

# Case 5: Four Lines Out

## 3,000 MW transfer – 1, 500 MW per line

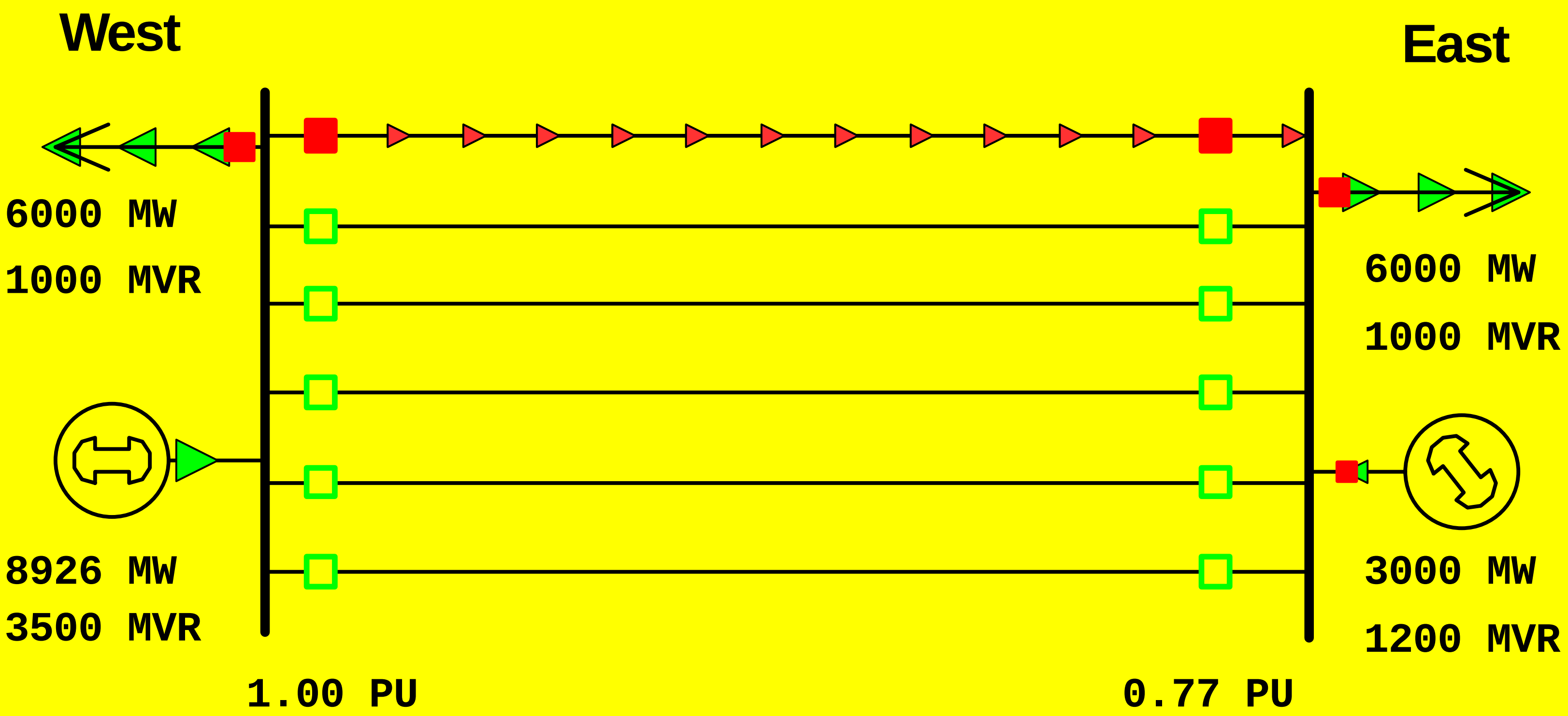



Voltage has dropped to 97% of rated voltage (957 MVARs required by lines).

East generator is at 1,200 MVAR limit.

# Case 6: Five Lines Out

# Voltage Collapse




**This simulation could not solve the case of 3,000 MW transfer with five lines out. Numbers shown are from the model's last attempt to solve. The West generator's unlimited supply of VARs is still not sufficient to maintain the voltage at the East bus.**